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A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)
JUN 82 N62742-81-C-0006
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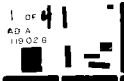

(1)

CONTRACT NO. N62742-81-C-0006

A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BULK FUEL TERMINALS AT N.S.C., PEARL HARBOR, HAWAII

VOLUME II

JUNE 1982

PACIFIC CORROSION RESEARCH, INC.
5481 B COMMERCIAL DRIVE
HUNTINGTON BEACH, CALIFORNIA 92649

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"Original contains color plates: All DTIC reproductions will be in black and white"

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150,000 BBL TANKS IN THE PEARL CITY TANK FARM

SECTION C-1

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment of Section C-1 can be classified as an area of severe corrosion potential.

B. The fuel tanks of Section C-1 were found to be electrically continuous with the POL lines of Sections A-1, A-2, A-4 and A-5.

C. It was found that the external bottom surface areas of the fuel tanks were not receiving full cathodic protection during this survey.

D. Approximately 74,900 sq. ft. of steel structures (external tank bottom surface areas) are to be considered for cathodic protection in Section C-1. Approximately 35 amperes D.C. will be required to provide a protective potential.

2. Recommendations:

A. For protection of Section C-1, a new anode bed consisting of one oil cooled rectifier and ten (10) 4 3/4"x84" high silicon iron tubular anodes be installed south of Tank #3 (S88) as recommended in Section A-2.

B. The existing anode bed of Rectifier #11 should be replaced with 4½"x60" high silicon iron anodes as recommended in Section A-5.

C. During this survey, we were advised by Mr. Jim Gammon, Superintendent, Fuel Department, NSC, that existing Tank #4 will be replaced with a new steel tank. A new cathodic protection system for the new steel tank has been designed by the Pacific Division engineers. Per Mr. Gammon's request, the designed system was reviewed by PCR engineers. The following recommendations were made in December of 1981:

(1) Rectifier - Oil cooled rectifier with low voltage capacity

should be used.

(2) Anode Beds - Anode bed should be installed away from the HIRI line.

(3) Anodes - High silicon iron anodes should be used.

(4) Resistance Bond Station - A resistance bond station should be installed between the Navy owned POL line and the HIRI line at the location south of Tank #4.

SECTION C-1

THIS SECTION INCLUDES ONE 25,000 BBL, TWO 80,000 BBL AND TWO 150,000 BBL TANKS IN THE PEARL CITY TANK FARM

1. Description.

   A. Lines to be Protected:

   (1) One 25,000 BBL Tank (S775) - Above ground steel tank

   (2) Two 80,000 BBL Tanks (S93 & S94) - Above ground steel tanks

   (3) Two 150,000 BBL Tanks (S87 & S88) - Above ground steel tanks

   B. Existing Cathodic Protection System:

   The external bottom surface areas of these five fuel storage tanks were originally designed to be cahtodically protected by existing Rectifier #11 as mentioned in Sections A-2 and A-5.

   a. Rectifier Location: Rectifier #11 is located southwest of the Pearl City Tank Farm.

   b. Rectifier Unit: Mfg. - Electrical Facilities, Inc. Oakland, CA.
   Serial No. - Unknown (no name plate)
   D.C. Capactity - 20 V, 50 A
   Operating at - Tap setting 5-4
   D.C. Output - 3.5 V, 13 A
   Date Recorded - October 10, 1981

   c. Anode Bed Location: Three sections of railroad tracks were installed 5' east of Kalapo Canal and approximately 350'

north of Waipuna Avenue.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of fifteen sets of measurements were obtained at representative locations around the tanks as shown in Table No. XVI-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	73	Severe
Medium	2,000 - 10,000	27	Moderate
High	10,000 - 30,000	0	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Seventy-three percent of the measurements obtained were in the severe category and twenty-seven percent were in the medium or moderate category.

B. "As Found" Pipe-to-Soil Potentials: "As Found" pipe-to-soil potentials were obtained at four sides of each tank. The measurements obtained indicated that the external bottom surface areas of the tanks are not receiving full protection with a majority of the readings below -850 mv. Lower potentials were found at Tank #4 (S87) of the Pearl City Tank Farm. The results of these measurements are shown in Table No. XVI-B in the appendix of this report.

C. Current Tests: A total of three current tests were conducted on this section of tanks. Pipe-to-soil potentials were obtained at each side of the fuel tanks during each test.

(1) Current Test No. 1 - This current test was conducted in the area southwest of the Pearl City Tank Farm. Pipe-to-soil potentials were obtained at each side of the tanks with existing Rectifier #11 "off" and "on". During this test, existing Rectifier #11 was operating at a tap setting of 5 (coarse) - 4 (fine) providing 3.5 volts and 13 amperes D.C.. The results of this test are shown in Table No. XVI-C.

(2) Current Test No. 2 - This current test was conducted with the same anode bed configuration and negative connection as Current Test No. 1. The current was increased to 27.5 amperes D.C.. The results are shown in Table No. XVI-D.

(3) Current Test No. 3 - This current test was conducted with the following conditions:

a. Existing Rectifier #11 was operating at a tap setting of 10 (coarse) - 4 (fine), providing 7.5 volts and 27.5 amperes D.C.. During performance of this test, this rectifier was turned "on" all the time.

b. Fifteen steel rods were installed north of Tank #3 as a temporary anode bed. The negative from a test rectifier was connected to the 12" JP-4 line in VC-3. The current used for this test was 24 amperes D.C.

The results of this test are shown in Table No. XVI-E. Based on the data obtained from these current tests, the following results were observed:

(i) All tanks were found to be electrically continuous with each other.

(ii) The tanks were found to be electrically continuous with the POL lines of Sections A-1, A-2, A-4 and A-5.

(iii) The results of the current tests indicate that the current demand for the external bottom surface areas of the fuel tanks will be moderate.

D. Leak History: We were advised by Base Fuel Personnel that Tank #4 had numerous leaks in the past and will be replaced with a new steel tank.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. The results of the soil resistivity measurements indicate that 73% of the readings are in the severe category and 27% are in the moderate category. Generally, the environment of Section C-1 can be classified as an area of severe corrosion potential.

B. The fuel tanks of Section C-1 were found to be electrically continuous with the POL lines of Sections A-1, A-2, A-4 and A-5.

C. It was found that the external bottom surface areas of the

fuel tanks were not receiving full cathodic protection during this survey.

D. The results of current tests conducted indicated that the current demand for the external bottom surface areas of the fuel tanks will be moderate. Approximately 74,900 sq. ft. of steel structures are to be considered for cathodic protection in Section C-1. Approximately 35 amperes D.C. will be required to provide a protective potential.

4. Recommendations.

A. For protection of Section C-1, a new anode bed consisting of one oil cooled rectifier and ten 4 3/4" x 84" high silicon iron tubular anodes be installed south of Tank #3 (S88) as recommended in Section A-2.

B. The existing anode bed of Rectifier #11 should be replaced with 4½" x 60" high silicon iron anodes as recommended in Section A-5.

C. During this survey, we were advised by Mr. Jim Gammon, Superintendent, Fuel Department, NSC, that existing Tank #4 will be replaced with a new steel tank. A new cathodic protection system for the new steel tank has been designed by the Pacific Division engineers. Per Mr. Gammon's request, the designed system was reviewed by PCR engineers. The following recommendations were made in December of 1981:

(1) Rectifier - Oil cooled rectifier with low voltage capacity should be used.

(2) Anode Bed - Anode bed should be installed away from the HIRI line.

(3) Anodes - High silicon iron anodes should be used.

(4) Resistance Bond Station - A resistance bond station should be installed between the Navy owned POL line and the HIRI line at the location south of Tank #4.

On May 12, 1982, PCR was again requested by Mr. Jim Gammon to review the cathodic protection system design, including specifications, which had been revised by the Navy engineers.

A final recommendation of the revised system and its specifications were made and submitted to Mr. Gammon on May 25, 1982.

It is recommended that the cathodic protection system for the new Tank #4 at the Pearl City Tank Farm be isolated from the existing system by installation of insulators, test boxes and resistance bond stations.

NOTE: The locations of pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6505.
The recommended C.P. system is shown on PCR Drawing No. 6505-A, for Section C-1.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 1

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-1

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
THE RECOMMENDED C.P. SYSTEMS IN SECTIONS								
A-2 AND A-5 WILL ALSO PROVIDE PROTECTIVE								
CURRENT FOR THE EXTERNAL TANK BOTTOM								
AREAS OF THIS SECTION.								

S/N 0105-LF-010-1335

★ G P O : 1979-689-016/4302

SECTION C-1

SOIL RESISTIVITIES

TABLE NO. XVI-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	N of Tank S-87	1200	460	480
2.	W of Tank S-87	1400	560	520
3.	S of Tank S-87	1300	440	480
4.	E of Tank S-88	900	310	280
5.	N of Tank S-88	1400	460	520
6.	W of Tank S-88	1000	300	480
7.	W of Tank 775	1800	1000	760
8.	S of Tank 775	1700	1200	640
9.	E of Tank 775	1600	1000	680
10.	N of Tank S-94	3800	2600	760
11.	E of Tank S-94	4000	2800	880
12.	W of Tank S-94	2600	2400	760
13.	E of Tank S-93	3200	2200	560
14.	S of Tank S-93	3400	2400	640
15.	W of Tank S-93	3100	2600	600

SECTION C-1

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XVI-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Tank #1 (S93)	
	N. side	-830
	E. side	-835
	S. side	-840
	W. side	-850
2.	Tank #2 (S94)	
	N. side	-790
	E. side	-795
	S. side	-810
	W. side	-830
3.	Tank #B-1 (S775)	
	N. side	-865
	E. side	-850
	S. side	-860
	W. side	-880
4.	Tank #3 (S88)	
	N. side	-760
	E. side	-850
	S. side	-795
	W. side	-800
5.	Tank #4 (S87)	
	N. side	-660

E. side	-620
S. side	-655
W. side	-650

SECTION C-1

CURRENT TEST NO. 1

TABLE NO. XVI-C

Location: Existing Rectifier #11, SE. of of Tank #1 (S93)

Anodes used for current test: Existing anode bed.

Negative Connection: Existing negative.

Rectifier D.C. Output: 3.5 volts - 13 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank #1 (S93)			
	N. side	-750	-830	90
	E. side	-745	-835	90
	S. side	-760	-840	80
	W. side	-765	-850	85
2.	Tank #2 (S94)			
	N. side	-720	-790	70
	E. side	-730	-795	75
	S. side	-740	-810	70
	W. side	-755	-830	75
3.	Tank #B-1 (S775)			
	N. side	-760	-865	105
	E. side	-760	-850	90
	S. side	-770	-860	90
	W. side	-780	-880	100
4.	Tank #3 (S88)			
	N. side	-710	-760	50
	E. side	-720	-775	55

	S. side	-735	-795	60
	W. side	-745	-800	55
5.	Tank #4 (S87)			
	N. side	-630	-660	30
	E. side	-650	-670	20
	S. side	-635	-655	20
	W. side	-640	-650	10

SECTION C-1

CURRENT TEST NO. 2

TABLE NO. XVI-D

Location: Existing Rectifier #11, SE. of Tank #1 (S93)

Anodes used for current test: Existing anode bed.

Negative connection: Existing negative.

Rectifier D.C. Output: The current output of existing Rectifier #11 was increased to 7.5 volts - 27.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank #1 (S93)			
	N. side	-740	-1040	300
	E. side	-745	-1050	305
	S. side	-760	-1050	290
	W. side	-765	-1055	290
2.	Tank #2 (S94)			
	N. side	-720	-990	270
	E. side	-730	-935	205
	S. side	-740	-945	205
	W. side	-755	-950	195
3.	Tank #B-1 (S775)			
	N. side	-760	-1090	330
	E. side	-760	-1070	310
	S. side	-770	-1065	295
	W. side	-780	-1060	280
4.	Tank #3 (S88)			
	N. side	-710	-880	170

	E. side	-735	-960	225
	W. side	-745	-970	225
5.	Tank #4 (S87)			
	N. side	-630	-720	90
	E. side	-650	-730	80
	S. side	-635	-655	20
	W. side	-640	-650	10

SECTION C-1

CURRENT TEST NO. 3

TABLE NO. XVI-E

Location: VC-3

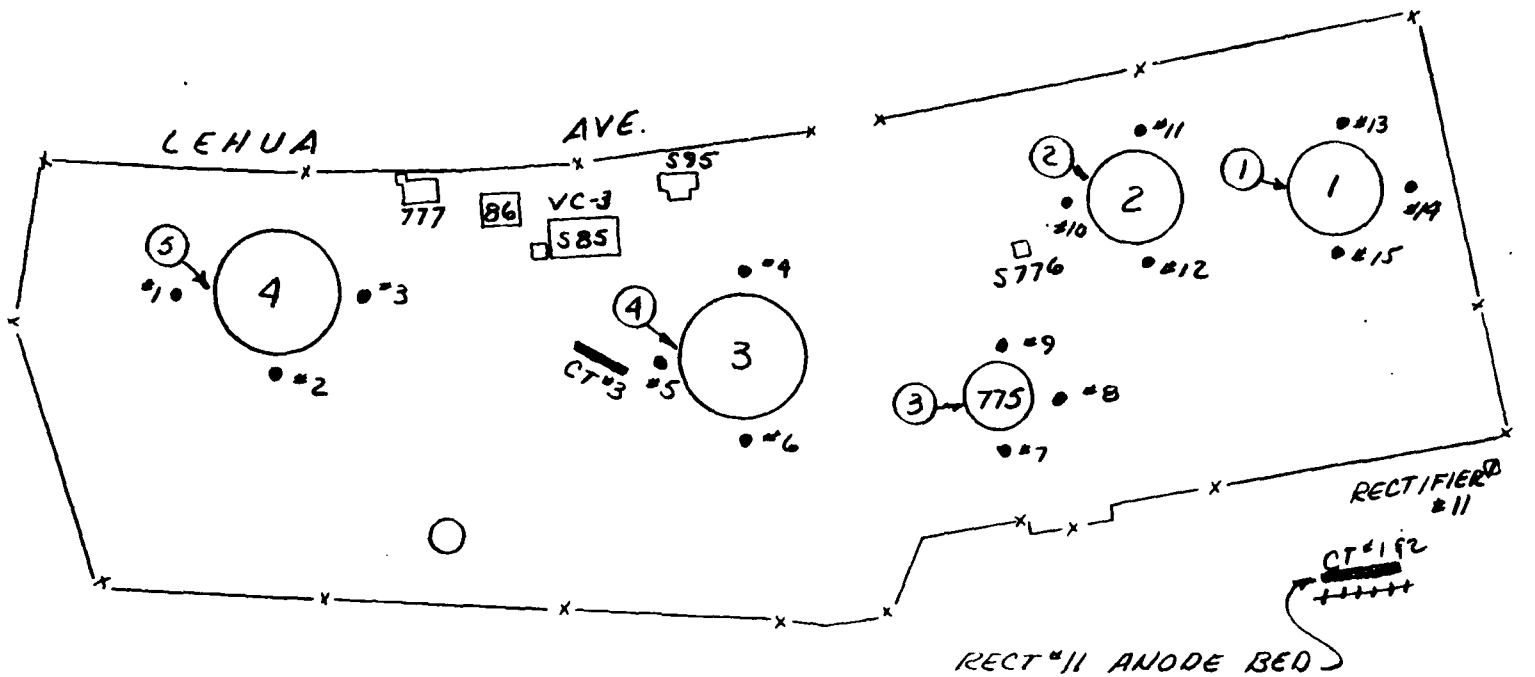
Anodes used for current test: New anode bed consisting of 15 steel rods installed north of Tank #3.

Negative connection: To JP-4 lines at VC-3.

Rectifier D.C. Output: 33 volts - 24 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank #1 (S93)			
	N. side	-1040	-1100	60
	E. side	-1050	-1110	60
	S. side	-1050	-1050	0
	W. side	-1055	-1055	0
2.	Tank #2 (S94)			
	N. side	- 990	-1050	60
	E. side	- 935	- 995	60
	S. side	- 945	-1000	55
	W. side	- 950	-1005	55
3.	Tank #B-1 (S775)			
	N. side	-1090	-1190	100
	E. side	-1070	-1170	100
	S. side	-1065	-1160	100
	W. side	-1060	-1170	110
4.	Tank #3 (S88)			
	N. side	- 880	-1340	460

	E. side	-940	-1220	280
	S. side	-960	-1240	280
	W. side	-970	-1245	275
5.	Tank #4 (S87)			
	N. side	-720	- 840	210
	E. side	-730	- 855	205
	S. side	-635	- 950	315
	W. side	-650	- 920	280



PEARL CITY TANK FARM

N

LEGEND

- #1 — SOIL RESISTIVITY LOCATION
- 1 — PIPE-TO-SOIL POTENTIAL LOCATION
- CT #1 — CURRENT TEST LOCATION
- EXISTING RECTIFIER
- EXISTING ANODE BED

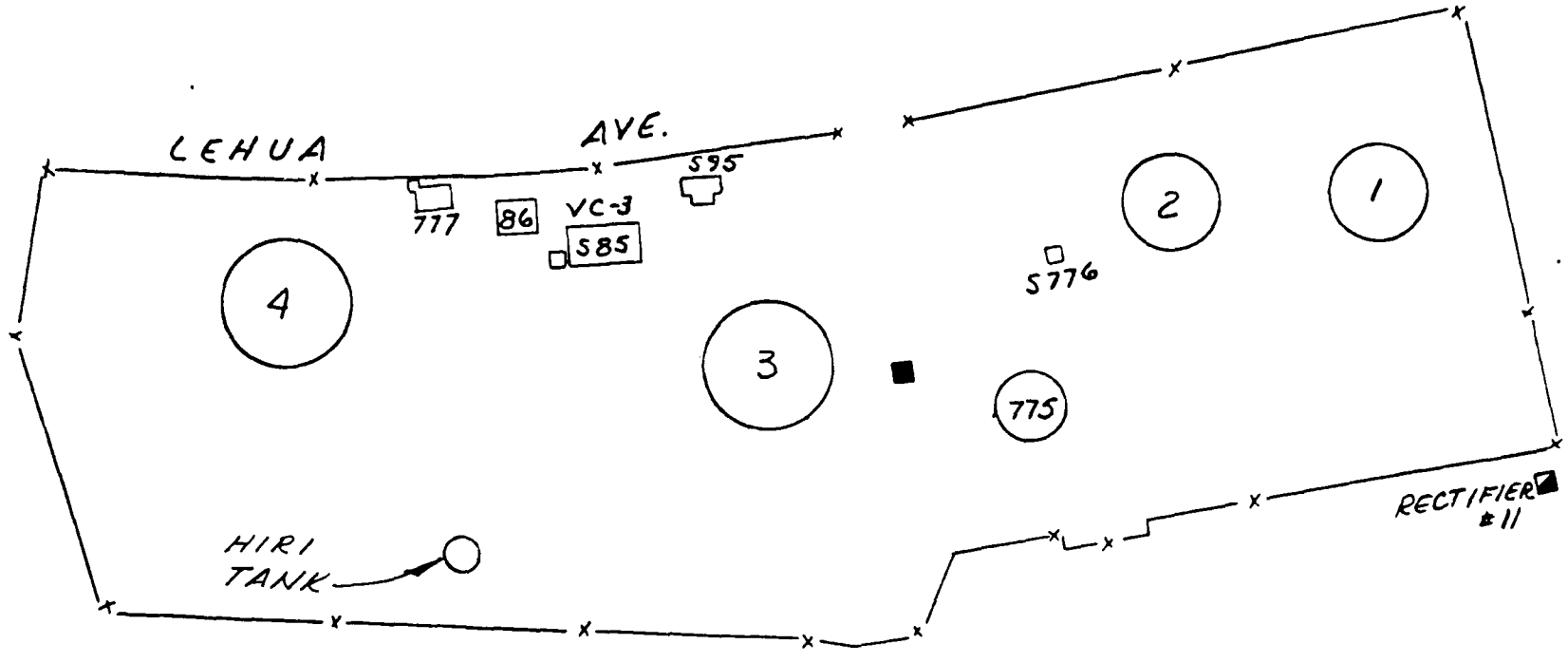
SCALE: NONE

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

FIELD DATA	SECTION: C-1
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: T.J.O.	NUMBER: 6505



PEARL CITY TANK FARM

N

L E G E N D

■ INSTALL A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES.

◪ REPLACED EXISTING RECTIFIER #11 WITH A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES.

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: C-1
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: H. T30	NUMBER: 6505A

SECTION C-2

THIS SECTION IS THE TANKS IN THE UPPER TANK FARM CONSISTING OF SIX 150,000 BBL TANKS, EIGHT UNDERGROUND DIESEL STORAGE TANKS AT BUILDING 60, FOUR 10,000 BBL UNDERGROUND SURGE TANKS, TWO BALLAST TANKS, TWO DIESEL TANKS, ONE HOT SETTLING TANK AND ONE DIESEL FLOTATION TANK

SECTION C-2

THIS SECTION IS THE TANKS IN THE UPPER TANK FARM CONSISTING OF SIX 150,000 BBL TANKS, EIGHT UNDERGROUND DIESEL STORAGE TANKS AT BUILDING 60, FOUR 10,000 BBL UNDERGROUND SURGE TANKS, TWO BALLAST TANKS, TWO DIESEL TANKS, ONE HOT SETTLING TANK AND ONE DIESEL FLOTATION TANK

SECTION C-2

SUMMARY

1. Conclusions:

Based on the field data obtained, the following conclusions are made:

A. The soil environment in Section C-2 can be classified as an area of moderate to severe corrosion potential.

B. The tanks of Section C-2 are not at a protective potential level.

C. Tank #53, Tank #S764 and Tank #S765 are not electrically continuous with the other tanks and piping system of Section C-1. Tanks and piping systems of Section C-2 with exception of the above mentioned three tanks were found to be electrically continuous with Sections B-1 thru B-9.

D. The cast iron water main around the Upper Tank Farm is not electrically continuous with the tanks of Section C-2.

E. Approximately 170,000 sq. ft. of ferrous lines and structures should be considered for cathodic protection. A protective current of 150 amperes D.C. will be required to provide a protective potential level.

2. Recommendations:

A. The results of the field data obtained indicated that the current demand for protection of the tanks of Section C-2 will require four new anode beds.

(1) Anode Bed #1 - This anode bed will consist of one oil cooled rectifier and sixteen (16) 4"x40" graphite anodes which should be installed around the four underground steel tanks (S1224 thru S1227).

(2) Anode Bed #2 - This anode bed will consist of one new oil cooled rectifier and ten 4"x40" graphite anodes which should be installed in the area northwest of Tank #48.

(3) Anode Bed #3 - This anode bed will consist of one oil cooled rectifier and fifteen (15) 4½"x60" high silicon iron anodes which should be installed east of Tanks #46, #47 and #48.

(4) Anode Bed #4 - This anode bed will consist of one oil cooled rectifier and fourteen (14) 4"x40" graphite anodes installed southwest of Pumphouse #59 as recommended in Section B-5.

B. It is recommended that a test lead of #6 AWG HMP stranded copper cable be installed at each of the four underground steel tanks in order to perform further field tests in the future.

SECTION C-2

THIS SECTION IS THE TANKS IN THE UPPER TANK FARM CONSISTING OF SIX 150,000 BBL TANKS, EIGHT UNDERGROUND DIESEL STORAGE TANKS AT BUILDING 60, FOUR 10,000 BBL UNDERGROUND SURGE TANKS, TWO BALLAST TANKS, TWO DIESEL TANKS, ONE HOT SETTLING AND ONE DIESEL FLOTATION TANK

1. Description.

A. Structures to be protected:

(1) Six 150,000 BBL Tanks (S54, S55, S56, S61, S62, & S63) - Underground steel tanks

(2) Eight Diesel Storage Tanks- Uncerground concrete tanks

(3) Four 10,000 BBL Surge Tanks (S1224, S1225, S1226 & S1227) - Underground steel tanks

(4) Two Ballast Tanks (S764 & S765) - Above ground steel tanks

(5) Two Diesel Tanks (S767 & S768) - Above ground steel tanks

(6) Two Sludge Tanks (S769 & S770) - Above ground steel tanks

(7) One Settling Tank - Above ground steel tank

(8) One Flotation Tank - Above ground steel tank

B. Existing Cathodic Protection System:

No cathodic protection system has been installed previously.

2. Field Work and Evaluation of Data.

A. Soil Resistivity Measurements: A total of twenty-two sets of soil resistivity measurements were obtained around these tanks as shown in Table No. XVII-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	1	Severe
Medium	2,000 - 10,000	92	Moderate
High	10,000 - 30,000	7	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. One percent of the measurements obtained were in the severe category and ninty-two percent were in the medium or moderate category.

B. "As Found" Structure-to-Soil Potentials: "As Found" potentials were obtained at various locations around each tank. The results of these measurements indicated that the tanks of Section C-2 are not at a protective potential level with a majority of the readings below -700 mv. The results of these measurements are shown in Table No. XVII-B.

C. Current Tests: A total of five current tests were conducted at various locations in the Upper Tank Farm area. Structure-to-soil potentials were obtained at representative locations around the tanks with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area north of Tank #53 (S761). Ten steel rods were installed 40' north of Tank #53 as a test anode bed. The negative from a test rectifier was connected to the existing grounding rod of Tank #54. The cur-

rent used for this test was 15 amperes D.C.. The results of this test are shown in Table No. XVII-C.

(2) Current Test No. 2 - This current test was conducted with the same anode configuration and negative connection as Current Test No. 1. The current was increased to 25 amperes D.C.. The results of this test are shown in Table No. XVII-D.

(3) Current Test No. 3 - This current test was conducted in the area north of Building 1613. Twelve steel rods were installed 40' south of Pumphouse 59 as a temporary anode bed. The negative from a test rectifier was connected to the 12" JP-5 line on the south side of Pumphouse 59. The current used for this test was 10 amperes D.C.. The results of this test are shown in Table No. XVII-E.

(4) Current Test No. 4 - This current test was conducted in the area north of Tank #53. Six steel rods were installed 40' north of Tank #53 as a temporary anode bed. The negative wire from a test rectifier was connected to Tank #53. The current used for this test was 4.7 amperes D.C.. The results of this test are shown in Table No. XVII-F.

(5) Current Test No. 5 - This current test was conducted in the area between Tanks #47 and #48. Nineteen steel rods were installed 50' southeast of Tank #48 as a test anode bed. The negative wire from a test rectifier was connected to the 12" DFM line at VC-9. The current used for this test was 34 amperes D.C.. The re-

sults of this test are shown in Table No. XVII-G.

Based on the data obtained from these tests, the following conclusions are submitted:

a. The results of the soil resistivity measurements indicate that 92% of the readings are in the moderate category. Generally, the environment of Section C-2 can be classified as an area of moderate to severe corrosion potential.

b. The fuel tanks of Section C-2 were found to be electrically continuous with the POL lines of Sections B-1 thru B-9.

c. Tanks S761, S764 and S765 were found to be electrically discontinuous with the other tanks and piping systems of this section.

d. All tanks in Section C-2 are not receiving adequate cathodic protection.

e. It was found that the current demand for protection of the tanks of Section C-2 will be high. For protection of the four underground steel tanks (S1224 thru S1227) it will be necessary to install an impressed current system by installing anodes around these tanks.

f. The cast iron water main around the Upper Tank Farm is not electrically continuous with the tanks and the piping system of Section C-2.

D. Leak History: We were advised by the base fuel personnel that a leak on the internal bottom of Tank #48 was found and repaired in 1969. Lube tanks #1 and #2 have been abandoned

due to leaks. The POL lines to these two tanks were found to be disconnected at the time of this survey.

3. Conclusions.

Based on the field data obtained, the following conclusions are made:

A. The results of soil resistivity measurements indicated that the environment in Section C-2 can be classified as an area of moderate to severe corrosion potential.

B. The tanks of Section C-2 are not at a protective potential level.

C. Tank #53, Tank S764 and S765 are not electrically continuous with the other tanks and piping system of Section C-1.

D. Tanks and piping systems of Section C-2 with exception of the above mentioned three tanks were found to be electrically continuous with Sections B-1 thru B-9.

E. The cast iron water main around the Upper Tank Farm is not electrically continuous with the tanks of Section C-2.

F. The results of the current tests conducted indicated that current demand for Section C-2 will be high. Approximately 170,000 sq. ft. of ferrous lines and structures should be considered for cathodic protection. A protective current of 150 amperes D.C. will be required to provide a protective potential level.

4. Recommendations.

A. The results of the field data obtained indicated that the current demand for protection of the tanks of Section C-2 will require four new anode beds.

(1) Anode Bed #1 - This anode bed will consist of one oil cooled rectifier, sixteen 4"x40" graphite anodes and an anode watering system which should be installed around the four underground steel tanks (S1224 thru S1227).

(2) Anode Bed #2 - This anode bed will consist of one oil cooled rectifier, ten 4"x40" graphite anodes and an anode watering system which should be installed in the area northwest of Tank #48.

(3) Anode Bed #3 - This anode bed will consist of one oil cooled rectifier, fifteen 4½"x60" high silicon iron anodes and an anode watering system which should be installed east of Tanks #46, #47 and #48.

(4) Anode Bed #4 - This anode bed will consist of one oil cooled rectifier, fourteen 4"x40" graphite anodes and an anode watering system installed southwest of Pumphouse 59 as recommended in Section B-5.

B. The cast iron fire mains were found to be electrically discontinuous from section to section during this survey. The cast iron fire mains around the Upper Tank Farm should be bonded across each joint with a #8 TW stranded copper cable. A resistance bond station should be installed between the cast iron fire mains and the POL lines near Fire Hydrant #469, as recommended in Section B-5.

C. It is recommended that a test lead of #6 AWG HMP stranded copper cable be installed at each of the four underground steel tanks in order to perform further field tests in the future.

NOTE: The locations of pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6506.

The recommended C.P. systems for Section C-2 are shown on PCR Drawing No. 6506-A.

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-2

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIERS	4	ea	1950.00	7800.00	600.00	2400.00	2550.00	10200.00
4"x40" GRAPHITE ANODES	40	ea	210.00	8400.00	150.00	6000.00	360.00	14400.00
4½"x60" HI SILICON IRON ANODES	15	ea	720.00	10800.00	150.00	2250.00	870.00	13050.00
COAL COKE BREEZE	17250	lb	0.23	3967.50	0.08	1380.00	0.31	5347.50
1" PVC CLASS 200, PLASTIC PIPE	3500	ft	0.75	2625.00	0.15	525.00	0.90	3150.00
#2 HMP, STRANDED COPPER CABLE	2200	ft	1.50	3300.00	0.15	330.00	1.65	3630.00
TEST LEADS	4	ea	75.00	300.00	150.00	600.00	225.00	900.00
CONCRETE PADS	4	ea	150.00	600.00	600.00	2400.00	750.00	3000.00
SPLIT BOLTS	62	ea	1.05	65.10	4.50	279.00	5.55	344.10
HOSE CONNECTION ADAPTERS	4	ea	7.50	30.00	7.50	30.00	15.00	60.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	5	rl	37.50	187.50	45.00	225.00	82.50	412.50
RUBBER TAPE	15	rl	4.50	67.50	7.50	112.50	12.00	180.00
PLASTIC TAPE	15	rl	4.50	67.50	7.50	112.50	12.00	180.00
ALUMINO-THERMAL WELDS	10	ea	3.00	30.00	37.50	375.00	40.50	405.00
TRENCH	2000	ft	-	-	4.50	9000.00	4.50	9000.00
TERRA TAPE	2200	ft	0.23	506.00	0.08	176.00	0.31	682.00

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: FEB. 1, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-2

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
SUBTOTAL				38768.60		26240.00		65008.60
10% MISC. MATERIALS & LABOR				3876.00		2624.00		6500.00
SUBTOTAL				42644.60		28864.00		71508.60
30% CONSTRUCTION PROFIT				12793.38		8659.20		21452.58
TOTAL				55437.98		37523.20		92961.18

S/N 0105-LF-010-1335

★ G.P.O.: 1979-689-016/4302

SECTION C-2

SOIL RESISTIVITIES

TABLE NO. XVII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	SE of Tank 53	13000	4600	4000
2.	NE of Tank 53	12000	4400	2400
3.	NW of Tank 53	11000	4200	3600
4.	SW of Tank 54	2600	3600	3200
5.	SE of Tank 54	4200	3200	2400
6.	NE of Tank 54	4300	3400	2800
7.	S of Tank 55	3900	4000	2800
8.	E of Tank 55	4000	3800	3200
9.	W of Tank 55	3800	3600	2400
10.	SE of Tank 48	3200	3200	3200
11.	NE of Tank 48	2500	3000	2800
12.	NW of Tank 48	2500	2800	2400
13.	N of Tank 47	4000	5200	3600
14.	E of Tank 47	4800	5400	2800
15.	S of Tank 47	4100	5600	3200
16.	N of Tank 46	3500	3800	3200
17.	E of Tank 46	3900	4000	3600
18.	S of Tank 46	3300	4200	4000
19.	NE of Tank S-769	3400	2800	2800
20.	Between Tanks 764 & 765	3600	2800	2800
21.	Between Tanks 767 & 768	10000	4400	2000
22.	Near Underground Tank 1227	13000	3200	3200

SECTION C-2

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XVII-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Tank #53 (S761)	
	S. side	-190
	E. side	-200
	N. side	-210
	W. side	-180
2.	Tank #46 (S754)	
	S. side	-640
	E. side	-645
	N. side	-660
	W. side	-655
3.	Tank #47 (S755)	
	S. side	-550
	E. side	-565
	N. side	-600
	W. side	-575
4.	Tank #54 (S762)	
	S. side	-580
	E. side	-560
	N. side	-590
	W. side	-605
5.	Tank #55 (S763)	
	S. side	-660

	E. side	-655
	N. side	-670
	W. side	-665
6.	Tank #48 (S756)	
	S. side	-620
	E. side	-630
	N. side	-680
	W. side	-650
7.	Tank # S769	
	S. side	-600
	E. side	-580
	N. side	-520
	W. side	-610
8.	Tank # S770	
	S. side	-580
	E. side	-570
	N. side	-480
	W. side	-560
9.	Tank L-2 (S765)	
	S. side	-510
	E. side	-525
	N. side	-530
	W. side	-520
10.	Tank L-1 (S764)	
	S. side	-440
	E. side	-485
	N. side	-480
	W. side	-460

11.	Tank S767	
	S. side	-795
	E. side	-780
	N. side	-790
	W. side	-800
12.	Tank S768	
	S. side	-800
	E. side	-790
	N. side	-810
	W. side	-870
13.	Hot Settling Tank	
	S. side	-650
14.	Diesel Floatation Unit	
	S. side	-600
15.	E. of Tank 1224	-540
16.	E. of Tank 1225	-430
17.	E. of Tank 1226	-420
18.	E. of Tank 1227	-460

SECTION C-2

CURRENT TEST NO. 1

TABLE NO. XVII-C

Location: Tank #53.

Anodes used for current test: Ten steel rods were installed north of tank #53 as a temporary anode.

Negative Connection: Tank #54.

Rectifier D.C. Output: 15 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 48			
	N. side	-680	-720	40
	E. side	-690	-750	60
	S. side	-710	-770	60
	W. side	-720	-730	10
2.	Tank 55			
	N. side	-720	-750	30
	E. side	-710	-755	45
	S. side	-730	-770	40
	W. side	-710	-750	40
3.	Tank 47			
	N. side	-590	-630	40
	E. side	-630	-665	35
	S. side	-610	-650	40
	W. side	-580	-640	60
4.	Tank 54			
	N. side	-630	-910	280
	E. side	-670	-950	280

	S. side	-680	-970	290
	W. side	-660	-930	270
5.	Tank 46			
	N. side	-710	-860	150
	E. side	-700	-860	160
	S. side	-680	-780	100
	W. side	-700	-810	110
6.	VC-9	-730	-760	30

SECTION C-2

CURRENT TEST NO. 2

TABLE NO. XVII-D

Location: Tank #53.

Anodes used for current test: Ten steel rods were installed north of Tank #53 as temporary anodes.

Negative Connection: Tank #54.

Rectifier D.C. Output: 25 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 48			
	N. side	-680	-740	60
	E. side	-690	-800	110
	S. side	-710	-820	110
	W. side	-720	-760	40
2.	Tank 55			
	N. side	-720	-780	60
	E. side	-710	-810	100
	S. side	-730	-850	120
	W. side	-710	-810	100
3.	Tank 47			
	N. side	-590	-650	60
	E. side	-630	-840	210
	S. side	-610	-790	180
	W. side	-580	-680	100
4.	Tank 54			
	N. side	-650	-910	260
	E. side	-680	-1090	410

	S. side	-690	-1100	410
	W. side	-660	-1090	430
5.	Tank 46			
	N. side	-710	-1060	350
	E. side	-700	-1050	350
	S. side	-680	-860	180
	W. side	-700	-920	220
6.	VC-9	-730	-790	60

SECTION C-2

CURRENT TEST NO. 3

TABLE NO. XVII-E

Location: 14" JP-5 Line at Bldg. 59

Anodes used for current test: New anode bed consisting of 12 steel rods installed north of Bldg. 1613.

Negative Connection: 14" JP-5 line at Bldg. 59.

Rectifier D.C. Output: 10 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 768, E. side	-790	-830	40
2.	Tank 767, W. side	-810	-850	40
3.	Tank L2 (765), E. side	-525	-510	-15*
4.	Tank L1 (764), W. side	-460	-455	-5*
5.	Tank 1224, underground	-540	-710	170
6.	Tank 1225, underground	-430	-490	60
7.	Tank 1226, underground	-420	-470	50
8.	Tank 1227, underground	-460	-490	30
9.	Tank S770, N. side	-590	-615	25
10.	Tank S769, N. side	-600	-650	50
11.	Tank 48, N. side	-660	-700	40
12.	Tank 55, N. side	-710	-735	25
13.	Settling Tank, N. side	-680	-710	30
14.	Flot'n Tank, N. side	-600	-650	50

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION C-2

CURRENT TEST NO. 4

TABLE NO. XVII-F

Location: Tank #53.

Anodes used for current test: New anode bed consisting of 10 steel rods installed north of Tank 53.

Negative connection: Tank 53.

Rectifier D.C. Output: 4.7 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	S. of Tank 53	-190	-1000	810
	E. of Tank 53	-200	-1000	800
	N. of Tank 53	-160	-1300	1140
	W. of Tank 53	-190	-1240	1050
2.	Two 6" lines above ground SW. of Tank 53	-400	- 340	-60*

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION C-2

CURRENT TEST NO. 5

TABLE NO. XVII-G

Location: East of VC-11, NW. of Tank #47

Anodes used for current test: Nineteen steel rods and short section of fence used as temporary anodes.

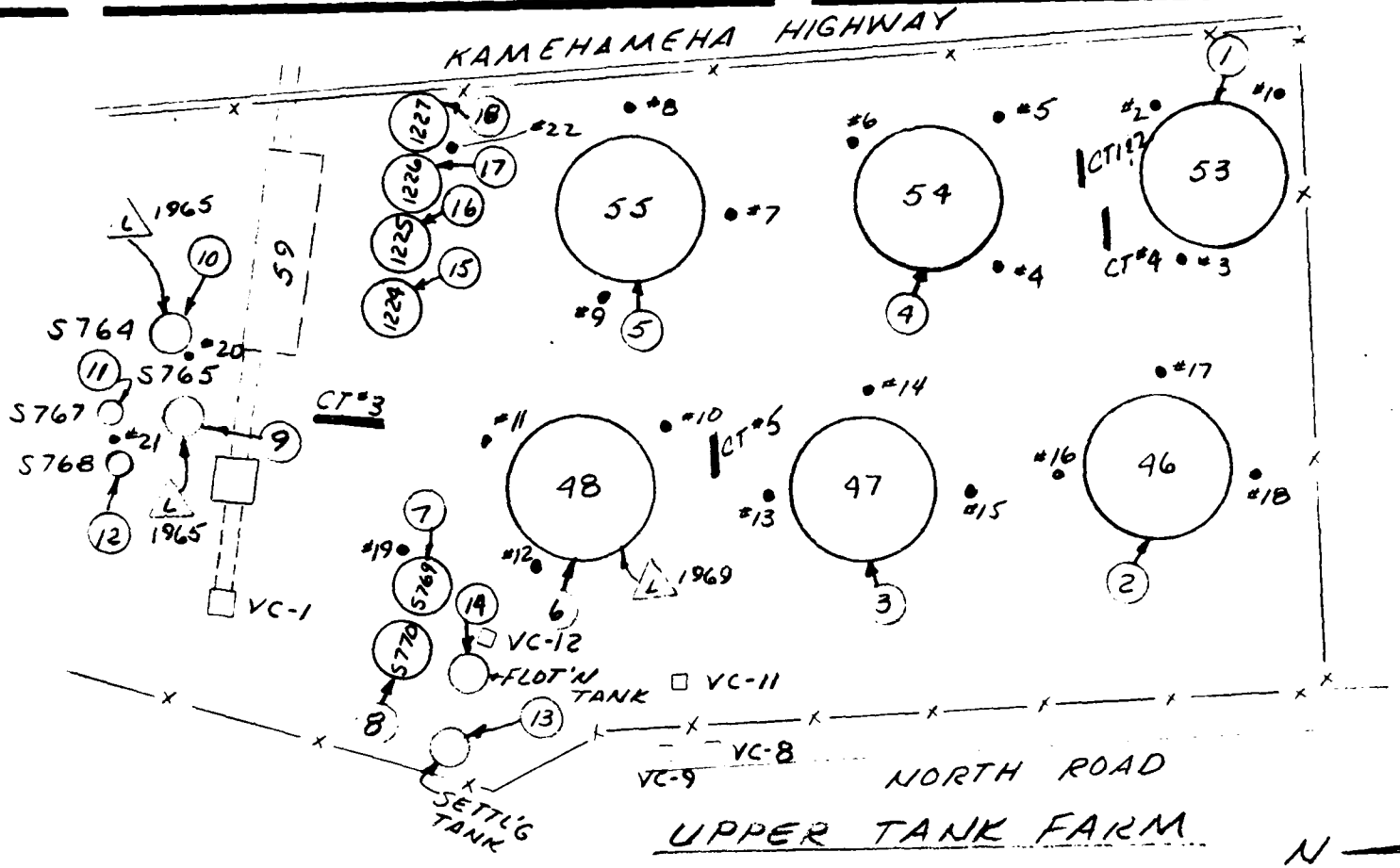
Negative connection: 12" DFM at VC-9.

Rectifier D.C. Output: 83 volts -35 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 53, 12" NSFO line	-210	-280	70
2.	12" NSFO, 120' W. of Tank 53, near fence	-265	-640	335
3.	Tank #46, 12" DFM line	-635	-710	75
4.	F.H. #467, W. of Tank 46	-500	-510	10
5.	Tank #47, 12" DFM	-565	-810	245
6.	F.H. #468, NW. of Tank #47	-500	-475	-25*
7.	F,H. #472, SW of Tank #54	-365	-360	-5*
8.	Tank #54, 12" DF,	-625	-770	145
9.	Tank #55, 10" Water	-680	-805	125
10.	Tank #55, 18" JP-5	-680	-805	125
11.	Tank #55, 12" JP-5	-680	-805	125
12.	Tank #48, 10" NSFO	-610	-850	240
13.	Tank #45, 12" Ballast	-545	-560	15
14.	Tank #45, 8" Ballast	-545	-560	15
15.	Tank S769, 10" line	-610	-680	70
16.	Two 4" Ballast Lines, Tank S769	-610	-680	70

17.	Tank S770, 8" Ballast	-610	-680	70
18.	Tank S770, two 4" Ballast	-610	-680	70
19.	Tank, five lines N. of Tank			
	4" U.G. Sump	-685	-735	70
	4" from Loading Rack	-685	-735	70
20.	12" Ballast line in pit SE of Tank #S769	-610	-685	75
21.	Float'n Tank, 8" Ballast line & 4" Ballast Line	-630	-685	55
22.	Settling Tank	-630	-685	55
23.	VC-12			
	8" Ballast to S-770	-620	-645	25
24.	VC-7 (all lines)	-660	-685	25
25.	VC-9	-680	-915	235

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of the test current.



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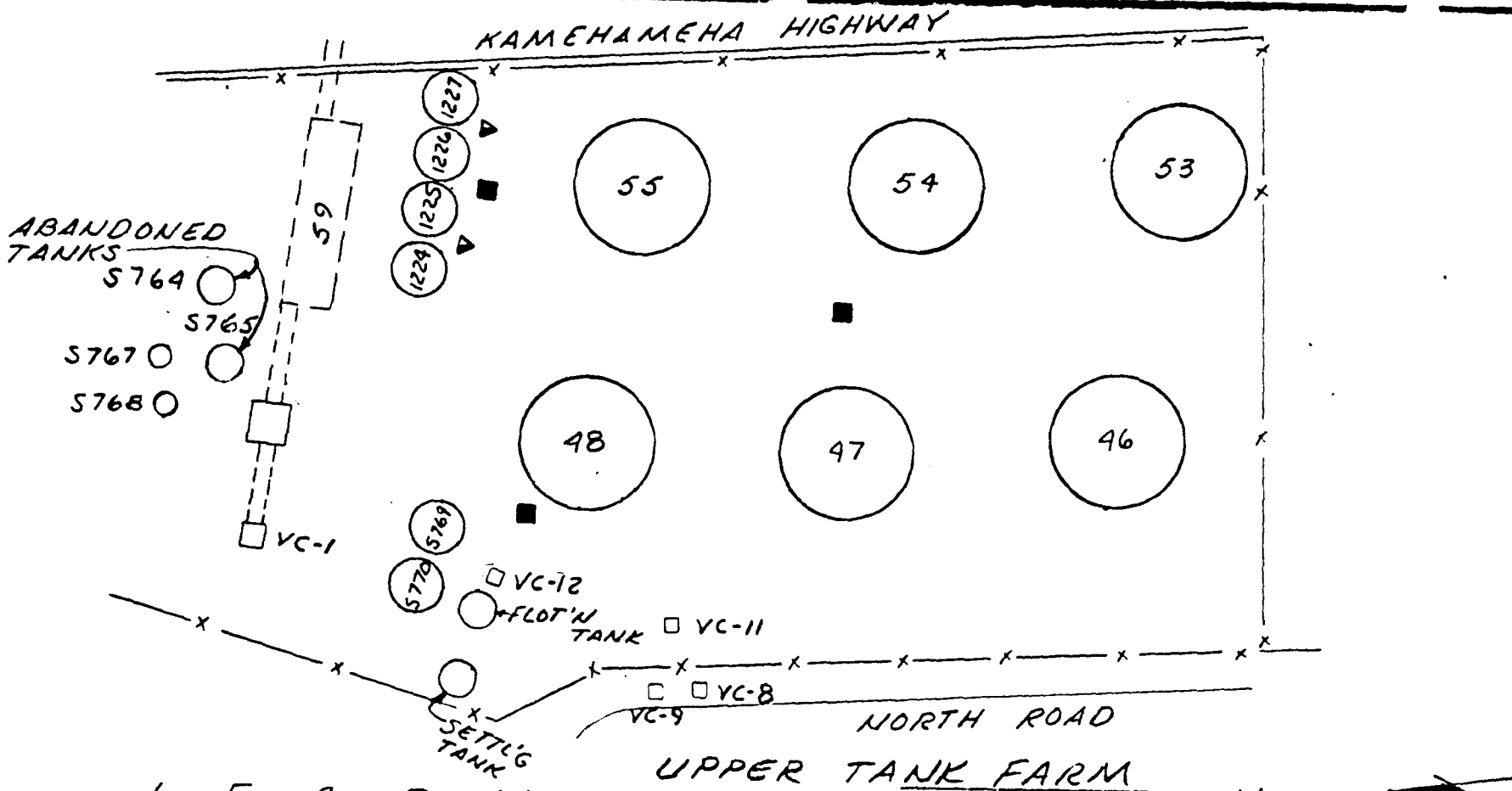
LEGEND

- ●#1 — SOIL RESISTIVITY LOCATION
- (1) — PIPE-TO-SOIL POTENTIAL LOCATION
- CT#1 — CURRENT TEST LOCATION
- L — LEAK LOCATION

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: C-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: J.T.S.	NUMBER: 6506



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LEGEND

▲ INSTALL NEW TEST BOX WITH TEST LEAD FROM EACH TANK

■ INSTALL NEW OIL COOLED RECTIFIER AND INSTALL GRAPHITE ANODES OR HIGH SILICON IRON TUBULAR ANODES

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED CP SYS.	SECTION: C-2
DRAWN: R.E.F.	DATE: 2-15-82
APPROVED: [illegible]	NUMBER: 6506-A

SECTION C-3

THIS SECTION INCLUDES FOUR 50,000 BBL TANKS AND ONE 80,000 BBL TANK

AT THE MIDDLE TANK FARM

SECTION C-3

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. The soil environment in Section C-3 can be classified as an area of moderate corrosion potential.

B. The external bottom surface areas of tanks in this section are not at a protective potential level.

C. This section of tanks are electrically continuous with the POL lines of Sections B-1 thru B-9. The cast iron fire mains around the Middle Tank Farm are also not electrically continuous with the tanks.

D. Existing Rectifier #9 does not provide adequate protective current for the tanks (Section C-3) and the POL lines (Section B-7).

E. Approximately 51,300 sq. ft. of steel lines and structures are to be considered for cathodic protection. Approximately 50 amperes D.C. will be required to provide a protective potential level.

2. Recommendations:

A. A new anode bed, which will consist of a new oil cooled rectifier and ten (10) 4"x40" graphite anodes should be installed in the southern area of the Middle Tank Farm, as recommended in Section B-7.

B. It is recommended that the existing anode bed of Rectifier #9 be replaced with twelve 4"x40" graphite anodes. These anodes should be installed in the northern area of the Middle Tank Farm. The existing Rectifier #9 should be replaced with a new oil cooled rectifier.

C. The cast iron fire mains, which were found to be electrically discontinuous with the POL lines and tanks, should be bonded with a No. 8 TW stranded copper cable, as recommended in Section B-7.

SECTION C-3

THIS SECTION INCLUDES FOUR 50,000 BBL TANKS AND ONE 80,000 BBL TANK AT THE MIDDLE TANK FARM

1. Description.

   A. Tanks to be protected:

      (1) One 80,000 BBL Tank - Above ground steel tank

      (2) Four 50,000 BBL Tanks - Above ground steel tanks

   B. Existing Cathodic Protection System:

      The tanks of Section C-3 and the POL lines of Section B-7 were originally designed to be protected by Rectifier #9 as mentioned in Section B-7.

      (1) Rectifier Location: Rectifier #9 is located on the west side of Building 553.

      (2) Rectifier Unit: Mfg. - Goodall
      Serial No. - 79C1380
      D.C. Capacity - 40 V, 80 A
      Operating at - Tap setting 4-5
      D. C. Output - 50 V, 9 A
      Date Recorded - August 24, 1981

      (3) Anode Bed Location: Nine 3"x60" graphite anodes were installed south of Building 229 in 1979.

2. Field Work and Evaluation of Data.

   A. Soil Resistivity Measurements: A total of fifteen sets of measurements were obtained around the tanks in Section C-3 as shown in Table No. SVIII-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	2	Severe
Medium	2,000 - 10,000	98	Moderate
High	10,000 - 30,000	0	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Two percent of the measurements obtained were in the severe category and ninty-eight percent were in the medium or moderate category.

B. "As Found" Tank-to-Soil Potentials: "As Found" tank-to-soil potentials were obtained at four sides of each tank. The results of these measurements indicated that the external bottom surface areas of the tanks in Section C-3 are not at a protective potential level. The results of these measurements are shown in Table No. XVIII-B.

C. Current Tests: Two current tests were conducted in the area of Section C-3. During performance of the current tests, the tank-to-soil potentials were obtained at various locations around the tanks with the test rectifiers "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area north of Bldg. 1557. Twelve steel rods were installed southwest of Tank #36 as a temporary anode bed. The negative wire from a test rectifier

was connected to the negative terminal at existing Rectifier #9. The current used for this test was 25 amperes D.C.. The results of this test are shown in Table No. XVIII-C.

(2) Current Test No. 2 - This current test was conducted in the area between Tanks #36 and #37. Twelve steel rods were installed 60' west of Tank #37 as a test anode bed. The negative wire from a test rectifier was connected to Tank #37. The current used for this test was 13.5 amperes D.C.. The results of this test are shown in Table No. XVIII-D.

Based on the data obtained, the following results were observed:

a. The tanks of Section C-3 are electrically continuous with the POL lines of Sections B-1 thru B-9.

b. Existing Rectifier #9 does not provide adequate protective current for the tanks of Section C-3.

c. The cast iron fire mains around the Middle Tank Farm are not electrically continuous with the POL lines (Section B-7) and the tanks (Section C-3) as mentioned in Section B-7.

d. The current demand for the tanks of Section C-3 will be high.

D. Leak History: We were advised by the base fuel personnel that no leaks were found in the past.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Soil resistivity measurements indicated that 98% of the readings are in the moderate category. The environment in Section C-3 can be classified as an area of moderate corrosion potential.

B. The external bottom surface areas of tanks in this section are not at a protective potential level.

C. This section of tanks are electrically continuous with the POL lines of Sections B-1 thru B-9. The cast iron fire mains around the Middle Tank Farm are also not electrically continuous with the tanks.

D. Existing Rectifier #9 does not provide adequate protective current for the tanks (Section C-3) and the POL lines (Section B-7).

E. The results of current tests conducted indicated that the current demand for the tanks of Section C-3 will be high. Approximately 51,300 sq. ft. of steel lines and structures are to be considered for cathodic protection. Approximately 50 amperes D.C. will be required to provide a protective potential level.

4. Recommendations.

A. A new anode bed, which will consist of a new oil cooled rectifier, ten 4"x40" graphite anodes and an anode watering systeym should be installed in the souther area of the Middle Tank Farm, as recommended in Section B-7.

B. It is recommended that the existing anode bed of Rectifier #9 be replaced with twelve 4"x40" graphite anodes. These anodes should be installed in the northern area of the Middle Tank Farm. The existing Rectifier #9 should be replaced

with a new oil cooled rectifier. An anode watering system should be installed along with the anode bed.

C. The cast iron fire mains, which were found to be electrically discontinuous with the POL lines and tanks, should be bonded with a No. 8 TW stranded copper cable, as recommended in Section B-7.

NOTE: The locations of pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6507.

The recommended C.P. systems for Section C-3 are shown on PCR Drawing No. 6507-A.

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-3

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIER	1	ea	1950.00	1950.00	600.00	600.00	2550.00	2550.00
4" x 40" GRAPHITE ANODES	12	ea	210.00	2520.00	150.00	1800.00	360.00	4320.00
COAL COKE BREEZE	3600	lb	0.30	1080.00	0.08	288.00	0.38	1368.00
CONCRETE PAD	1	ea	150.00	150.00	600,00	600.00	750.00	750.00
#2 HMP STRANDED COPPER CABLE	600	ft	1.50	900.00	0.15	90.00	1.65	990.00
1" PVC CLASS 200, PLASTIC PIPE	1000	ft	0.75	750.00	0.15	150.00	0.90	900.00
SPLIT BOLTS	15	ea	1.05	15.75	4.50	67.60	5.55	83.25
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
TERRA TAPE	600	ft	0.23	138.00	0.08	48.00	0.31	186.00
HOSE CONNECTION ADAPTER	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
ALUMINO-THERMIC WELDS	4	ea	3.00	12.00	37.50	150.00	40.50	162.00
TRENCH	600	ft	-	-	4.50	2700.00	4.50	2700.00
SUBTOTAL				7674.75		6726.00		14400.75
MATERIALS & LABOR				767.00		672.00		1440.00

S/N 0105-LF-010-1335
* G.P.O.: 1979-689 016/4302

NAVFAC 11013/7 (1 78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-3

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

ESTIMATED BY: H. TSO

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

IDENTIFICATION NUMBER

CATEGORY CODE NUMBER

JOB ORDER NUMBER

ITEM DESCRIPTION	QUANTITY NUMBER	QUANTITY UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
SUBTOTAL				8441.75		7398.00		15839.00
30% CONSTRUCTION PROFIT				2523.52		2219.40		4751.92
TOTAL				10974.27		9617.40		20591.67

S/N 0105-LF-010-1335

★ G P O : 1979-689-016/4302

SECTION C-3

SOIL RESISTIVITIES

TABLE NO. XVIII-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	SE of Tank 34	4400	3600	4000
2.	SW of Tank 34	4200	3800	3600
3.	NW of Tank 34	4700	3200	4400
4.	S of Tank 35	3700	4400	4000
5.	E of Tank 35	4800	4600	3600
6.	N of Tank 35	4800	4000	3600
7.	W of Tank 36	2600	2200	2000
8.	N of Tank 36	2800	2400	2400
9.	E of Tank 36	2900	2800	2800
10.	NW of Tank 37	6000	2600	2800
11.	NE of Tank 37	7000	2800	3600
12.	SE of Tank 37	8000	3200	4000
13.	S of Tank 38	4600	4800	5200
14.	E of Tank 38	4700	4200	4400
15.	N of Tank 38	4800	4400	4000

SECTION C-3

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XVIII-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Tank #34 (S746)	
	N. side	-585
	E. side	-580
	S. side	-560
	W. side	-565
2.	Tank #35 (S747)	
	N. side	-560
	E. side	-560
	S. side	-570
	W. side	-565
3.	Tank #36 (S748)	
	N. side	-590
	E. side	-580
	S. side	-610
	W. side	-595
4.	Tank #37 (S749)	
	N. side	-600
	E. side	-585
	S. side	-590
	W. side	-605
5.	Tank #38 (S750)	
	N. side	-660

E. side	-670
S. side	-665
W. side	-675

SECTION C-3

CURRENT TEST NO. 1

TABLE NO. XVIII-C

Location: SW. of Tank 36.

Anodes used for current test: New anode bed consisting of 12 steel rods installed SW. of Tank 36.

Negative Connection: To negative cable at existing Rectifier #9.

Rectifier D.C. Output: 15 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 34			
	N. side	-585	-610	25
	E. side	-560	-590	30
	S. side	-560	-600	40
	W. side	-560	-590	30
2.	Tank 35			
	N. side	-560	-615	55
	E. side	-560	-600	40
	S. side	-570	-600	30
	W. side	-565	-610	45
3.	Tank 36			
	N. side	-590	-640	50
	E. side	-580	-630	50
	S. side	-620	-660	40
	W. side	-595	-640	45
4.	Tank 37			
	N. side	-540	-570	30

E. side	-585	-610	25
S. side	-600	-630	30
W. side	-605	-630	25

5. Tank 38

N. side	-600	-715	55
E. side	-670	-720	50
S. side	-660	-680	20
W. side	-675	-685	10

SECTION C-3

CURRENT TEST NO. 2

TABLE NO. XVIII-D

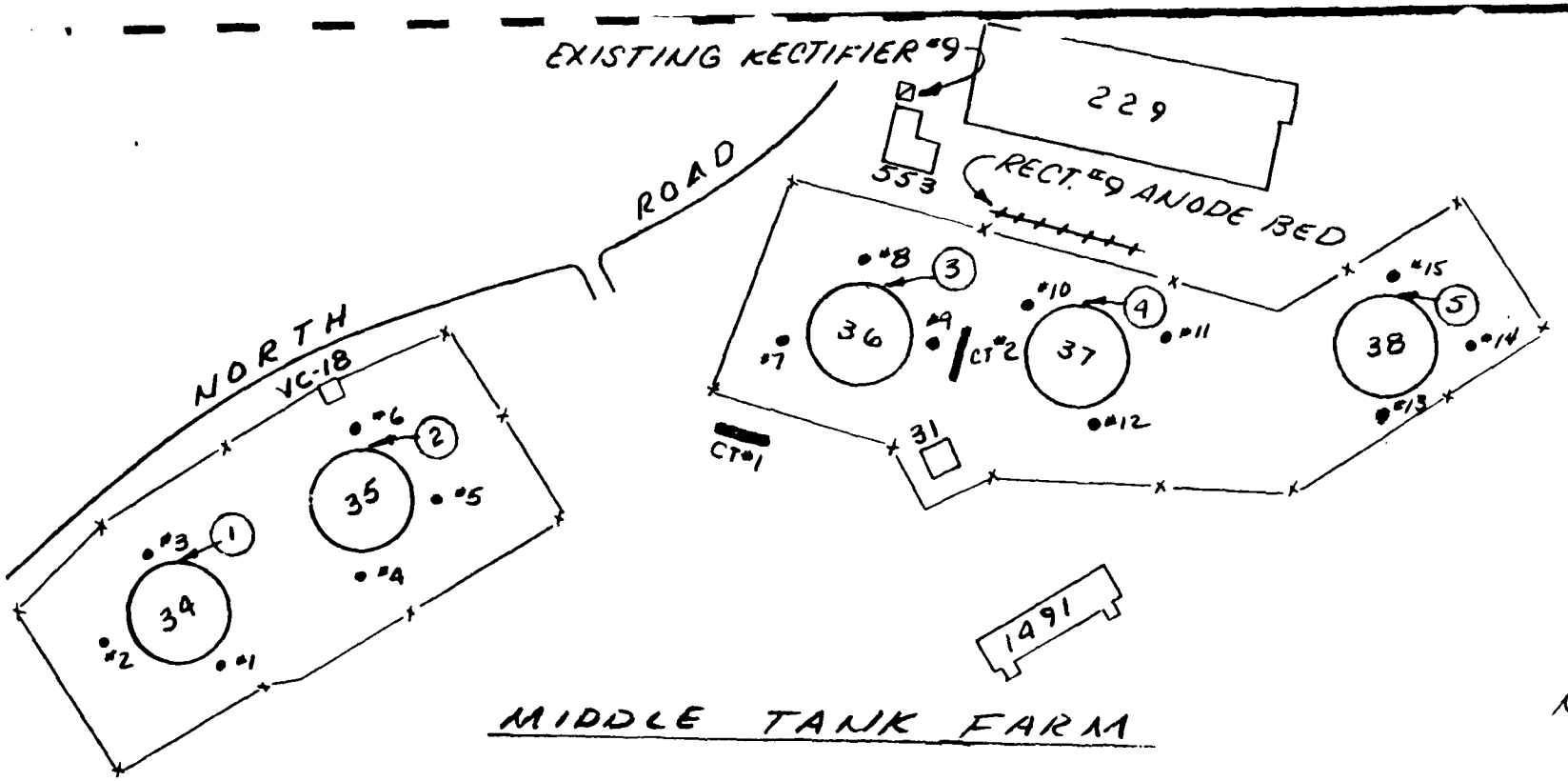
Location: Between tanks 36 & 37.

Anodes used for current test: New anode bed consisting of 12 steel rods installed between Tanks 36 & 37.

Negative connection: To Tank 37.

Rectifier D.C. Output: 13.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 36			
	SE. side	-620	-690	70
	E. side	-490	-580	90
	NW. side	-730	-910	180
	SW. side	-640	-780	140
2.	Tank 37			
	E. side	-640	-930	290
	N. side	-690	-780	90
	W. side	-700	-800	100
	S. side	-700	-880	180



MIDDLE TANK FARM

N

SCALE: NONE

LEGEND

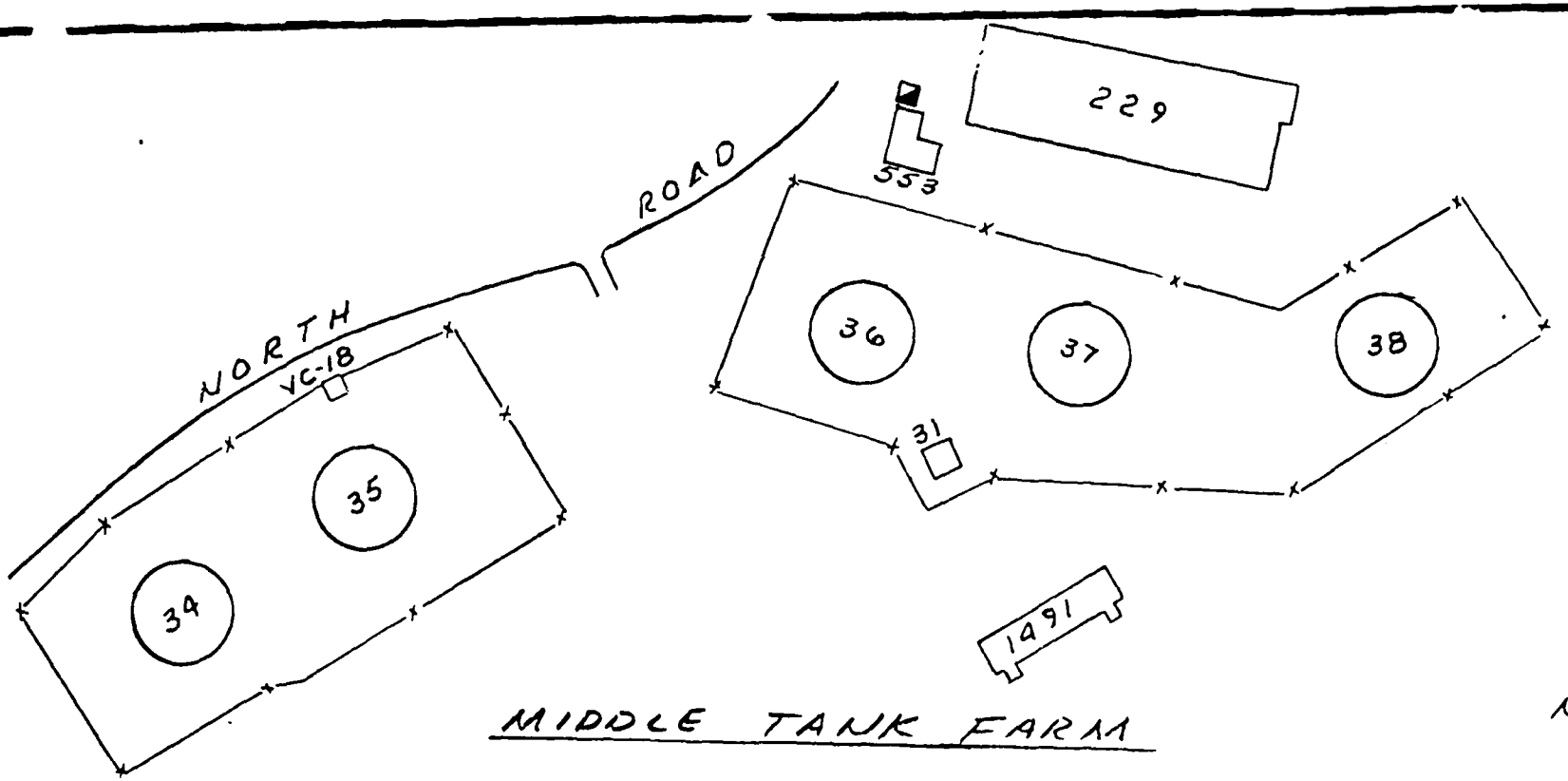
●#1	SOIL RESISTIVITY LOCATION
(1)→	PIPE-TO-SOIL POTENTIAL LOCATION
CT#1	CURRENT TEST LOCATION
⊠	EXISTING RECTIFIER
++++++	EXISTING ANODE BED

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

FIELD DATA	SECTION: C-3
DRAWN: R.E.F.	DATE: 2-16-82
APPROVED: H/TSO	NUMBER: 6507



MIDDLE TANK FARM

N

SCALE: NONE

LEGEND

■ REPLACE EXISTING RECTIFIER #9 WITH A NEW OIL COOLED RECTIFIER AND INSTALL NEW GRAPHITE ANODES

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: C-3
DRAWN: R.E.F.	DATE: 2-16-82
APPROVED: H/TH	NUMBER: 6507-A

SECTION C-4

THIS SECTION INCLUDES FOUR 50,000 BBL TANKS

AT THE LOWER TANK FARM

SECTION C-4

SUMMARY

1. Conclusions:

Based on the field data obtained, the following conclusions are submitted:

A. The soil environment in Section C-4 can be classified as an area of moderate corrosion potential.

B. The external bottom surface areas of tanks and the POL lines in the Lower Tank Farm are not at a protective potential level, with all potentials below -500 mv.

C. The POL lines and tanks in the Lower Tank Farm are electrically continuous with the following lines:

(1) The 8" POL line from Pumphouse 76 to an existing coupling dresser, west of Building 42.

(2) The foam lines in the Lower Tank Farm.

D. The POL lines and tanks in the Lower Tank Farm are not electrically continuous with the following lines:

(1) The 18" cast iron POL lines from Pumphouse 76 to the Navy Shipyard.

(2) The cast iron fire mains around the tanks.

E. The magnesium anodes installed around the tanks were found to have deteriorated and have exceeded their useful service life.

F. Approximately 45,000 sq. ft. of lines and structures are to be considered for cathodic protection. Approximately 45 amperes D.C. will be required to provide a protective potential level.

2. Recommendations:

A. The data obtained from the field indicate that a new anode bed consisting of one oil cooled rectifier and fourteen (14) 4"x80" graphite anodes

should be installed. The anodes should be installed around the tanks in the Lower Tank Farm. This system will provide protective current for the external bottom surface areas and the POL lines in Section C-4. This system will also provide partial protective current for the 8" NSFO line of Section B-6.

B. It is recommended that an insulator and a resistance bond station be installed on each of the following lines in Pumphouse 76:

(1) 18" POL lines to the Navy Shipyard (Section B-10).
(2) 8" NSFO line to VC-1 (Section B-6).

C. The cast iron fire main on the south side of the tanks should be bonded across each joint with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the cast iron fire main and the POL lines in the area south of Tank #11.

SECTION C-4

THIS SECTION INCLUDES THE FOUR 50,000 BBL TANKS

AT THE LOWER TANK FARM

1. Description.

   A. Tanks to be Protected:

      (1) Four 50,000 BBL Tanks - Above ground steel

   B. Existing Cathodic Protection System:

      The tanks were originally designed to be protected by a sacrificial anode type cathodic protection system. The magnesium anodes installed around the tanks were found to have deteriorated and were beyond their useful service.

2. Field Work and Evaluation of Data.

   A. Soil Resistivity Measurements: A total of sixteen sets of soil resistivity measurements were obtained at representative locations around the tanks in this section as shown in Table No. XIX-A. The results of these measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings	Anticipated Corrosion
Low	0 - 2,000	0	Severe
Medium	2,000 - 10,000	48	Moderate
High	10,000 - 30,000	52	Slight unless other factors are pronounced
Very High	Above - 30,000	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on underground metallic structures. Forty-eight percent of the measurements obtained were in the moderate category and fifty-two percent were in slight category.

B. "As Found" Structure-to-Soil Potentials: "As Found" potentials were obtained at four sides of each tank. The results of these measurements indicated that the external bottom surface areas of tanks in Section C-4 are not receiving any cathodic protection with all potentials below -500 mv. The results of these measurements are shown in Table No. XIX-B.

C. Current Tests: Two current tests were conducted in this section. During performance of the tests, the structure-to-soil potentials were obtained at various locations throughout the Lower Tank Farm site with the test rectifier "off" and "on".

(1) Current Test No. 1 - This current test was conducted in the area west of the Lower Tank Farm. The chain link fence around Pumphouse 76 was used as a test anode bed. The negative from a test rectifier was connected to the 12" NSFO line in Pumphouse 76. The current used for this test was 17.5 amperes D.C.. The results of this test are shown in Table No. XIX-C.

(2) Current Test No. 2 - This current test was conducted with anode bed configuration and negative connection as Current Test No. 1. The current used for this test was increased to 30 amperes D.C.. The results of this test are shown in Table No. XIX-D.

Based on the data obtained from these tests, the following is submitted:

a. The tanks of Section C-4 are electrically continuous with the 8" POL line of Section B-6 but discontinuous with the 18" cast iron POL line from Pumphouse 76 to Power Plant #1 in the restricted shipyard (Section B-10).

b. No insulators were found installed on the POL lines in Pumphouse 76.

c. The foam lines were found electrically continuous with the POL lines and tanks of Section C-4.

d. The cast iron fire mains around the Lower Tank Farm are not electrically continuous with the tanks of Section C-4.

e. The current demand for the tanks and POL lines of Section C-4 will be high.

D. Leak History: We were advised by the base fuel personnel that several leaks were found on the 24" POL lines and repaired in 1979.

3. Conclusions.

Based on the field data obtained, the following conclusions are submitted:

A. The results of the soil resistivity measurements indicate that 48% of the readings are in the moderate category. The environment in Section C-4 can be classified as an area of moderate corrosion potential.

B. The external bottom surface areas of tanks and the POL lines in the Lower Tank Farm are not at a protective potential

level with all potentials below -500 mv.

C. The POL lines and tanks in the Lower Tank Farm are electrically continuous with the following lines:

(1) The 8" POL line from Pumphouse 76 to an existing coupling dresser, west of Building 42.

(2) The foam lines in the Lower Tank Farm.

D. The POL lines and tanks in the Lower Tank Farm are not electrically continuous with the following lines:

(1) The 18" cast iron POL lines from Pumphouse 76 to the Navy Shipyard.

(2) The cast iron fire mains around the tanks.

E. The magnesium anodes installed around the tanks were found to have deteriorated and have exceeded their useful service life.

F. The results of current tests conducted indicated that the current demand for the tanks and POL lines of Section C-4 will be high. Approximately 45,000 sq. ft. of lines and structures are to be considered for cathodic protection. Approximately 45 amperes D.C. will be required to provide a protective potential level.

4. Recommendations.

A. The data obtained from the field indicate that a new anode bed consisting of one oil cooled rectifier, fourteen 4"x80" graphite anodes and an anode watering system should be installed. The anodes should be installed around the tanks in the Lower Tank Farm. This system will provide protective current for the external bottom surface areas and the POL lines in Section C-4. This system will also provide

partial protective current for the 8" NSFO line of Section B-6.

B. It is recommended that an insulator and a resistance bond station be installed on each of the following lines in Pumphouse 76:

(1) 18" POL lines to the Navy Shipyard (Section B-10).

(2) 8" NSFO line to VC-1 (Section B-6).

C. The cast iron fire main on the south side tanks should be bonded across each joint with a No. 8 TW stranded copper cable. A resistance bond station should be installed between the cast iron fire main and the POL lines in the area south of Tank #11.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6508.
The recommended C.P. System for Section C-4 is shown on PCR Drawing No. 6508-A.

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION C-4

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

ESTIMATED BY: H. TSO

STATUS OF DESIGN: [ ] PED [X] 30% [ ] 100% [ ] FINAL [ ] Other (Specify) _____

IDENTIFICATION NUMBER:

CATEGORY CODE NUMBER:

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIER	1	ea	1950.00	1950.00	600.00	600.00	2550.00	2550.00
4" X 80" GRAPHITE ANODES	14	ea	330.00	4620.00	150.00	2100.00	480.00	6720.00
COAL COKE BREEZE	4900	lb	0.30	1470.00	0.07	343.00	0.37	1813.00
CONCRETE PAD	1	ea	150.00	150.00	600.00	600.00	750.00	750.00
#2 HMP STRANDED COPPER CABLE	1400	ft	1.50	2100.00	0.15	210.00	1.65	2310.00
1" PVC CLASS 200 PLASTIC PIPE	2600	ft	0.75	1950.00	0.15	390.00	0.90	2340.00
RESISTANCE BOND STATION	1	ea	150.00	150.00	150.00	150.00	300.00	300.00
SPLIT BOLTS	18	ea	1.05	18.90	4.50	81.00	5.55	99.90
HOSE CONNECTION ADAPTER	1	ea	7.50	7.50	7.50	7.50	15.00	15.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	2	rl	37.50	75.00	45.00	90.00	82.50	165.00
RUBBER TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
PLASTIC TAPE	6	rl	4.50	27.00	7.50	45.00	12.00	72.00
ALUMINO-THERMIC WELDS	6	ea	3.00	18.00	37.50	225.00	40.50	243.00
TERRA TAPE	1400	ft	0.23	322.00	0.07	98.00	0.30	420.00
TRENCH	1400	ft	-	-	4.50	6300.00	4.50	6300.00
BONDING OF CAST IRON PIPE	1000	ft	3.00	3000.00	10.50	10500.00	13.50	13500.00

S/N 0105-LF-010-1335

* G P O : 1979-689-016/4302

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 24174

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM CORROSION SURVEY, SECTION C-4

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
SUBTOTAL				15907.90		21829.50		37737.40
10% MATERIALS & LABOR				1590.00		2182.00		3772.00
SUBTOTAL				17497.90		24011.50		41509.40
30% CONSTRUCTION PROFIT				5249.37		7203.45		12452.82
TOTAL				22747.27		31214.95		53962.22

S/N 0105-LF-010-1335

SECTION C-4

SOIL RESISTIVITIES

TABLE NO. XIX-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	S of Tank 10	14000	18000	9200
2.	W of Tank 10	13000	20000	10400
3.	N of Tank 10	15000	22000	10000
4.	E of Tank 10	13000	18000	9600
5.	W of Tank 11	12000	12000	6400
6.	N of Tank 11	14000	14000	5600
7.	S of Tank 11	13000	14000	6400
8.	E of Tank 11	13000	12000	6000
9.	W of Tank 13	18000	18000	3200
10.	N of Tank 13	16000	5400	3200
11.	S of Tank 13	16000	8600	3600
12.	E of Tank 13	15000	6800	2800
13.	W of Tank 17	23000	6800	2400
14.	S of Tank 17	12000	4400	3600
15.	E of Tank 17	14000	4600	3200
16.	N of Tank 17	10000	4200	2800

SECTION C-4

"AS FOUND" PIPE-TO-SOIL POTENTIAL MEASUREMENTS

TABLE NO. XIX-B

Rdg. No.	Location	Pipe-to-Soil Potentials (mv)
1.	Tank #10	
	N. side	-500
	E. side	-440
	S. side	-410
	W. side	-440
2.	Tank #11	
	N. side	-530
	E. side	-490
	S. side	-490
	W. side	-510
3.	Tank #13	
	N. side	-480
	E. side	-480
	S. side	-460
	W. side	-480
4.	Tank #4	
	N. side	-470
	E. side	-480
	S. side	-490
	W. side	-480

SECTION C-4

CURRENT TEST NO. 1

TABLE NO. XIX-C

Location: Pumphouse 76.

Anodes used for current test: Chain Link Fence

Negative connection: 12" NSFO line in Pumphouse 76.

Rectifier D.C. Output: 5.5 volts - 17.5 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 10			
	E. side	-440	-630	190
	W. side	-440	-630	190
2.	Tank 11			
	E. side	-490	-680	190
	W. side	-490	-720	230
3.	Tank 13			
	E. side	-480	-720	240
	W. side	-480	-690	210
4.	Tank 17			
	E. side	-480	-710	230
	W. side	-480	-720	240
5.	Fire Hydrant Line			
	E. of Tank #17	-440	-445	5
6.	All lines in Pumphouse 76	-490	-730	240
7.	Fire Hydrant #358	-530	-520	-10*
8.	Fire Hydrant #356	-490	-465	-25*

9.	Fire Hydrant #354	-440	-415	-25*
10.	Foam line, near F.H. #354	-490	-790	300
11.	Foam line, near F.H. #356	-480	-840	360

*A minus change indicates taht the pipe-to-soil potential became less negative as a result of application of test current.

SECTION C-4

CURRENT TEST NO. 2

TABLE NO. XIX-D

Location: Pumphouse 76.

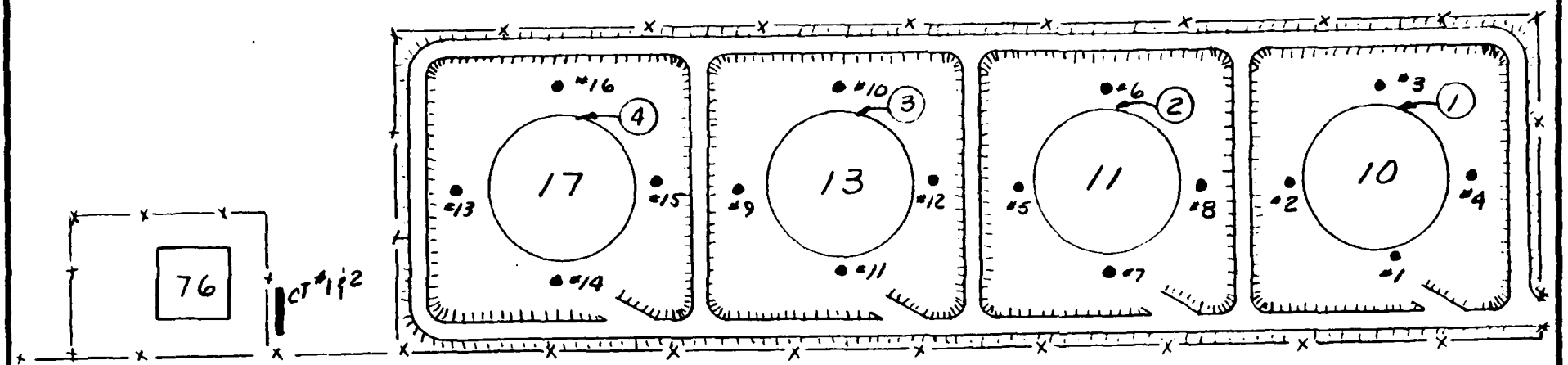
Anodes used for current test: Chain link fence.

Negative connection: 12" NSFO line in Pumphouse 76.

Rectifier D.C. Output: 10 volts - 30 amperes D.C.

Rdg. No.	Location	Pipe-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Tank 10			
	N. side	-500	-890	390
	E. side	-440	-760	320
	S. side	-410	-630	220
	W. side	-440	-760	320
2.	Tank 11			
	N. side	-530	-960	430
	E. side	-580	-820	240
	S. side	-490	-830	340
	W. side	-510	-880	370
3.	Tank 13			
	N. side	-480	-880	400
	E. side	-480	-880	400
	S. side	-460	-780	320
	W. side	-480	-830	350
4.	Tank 17			
	N. side	-480	-960	480
	E. side	-490	-880	390

S. side	-490	-880	390
W. side	-540	-940	400



← SOUTH ROAD →

← HICKAM A.F.B. →

N

LOWER TANK FARM

-495-

LEGEND

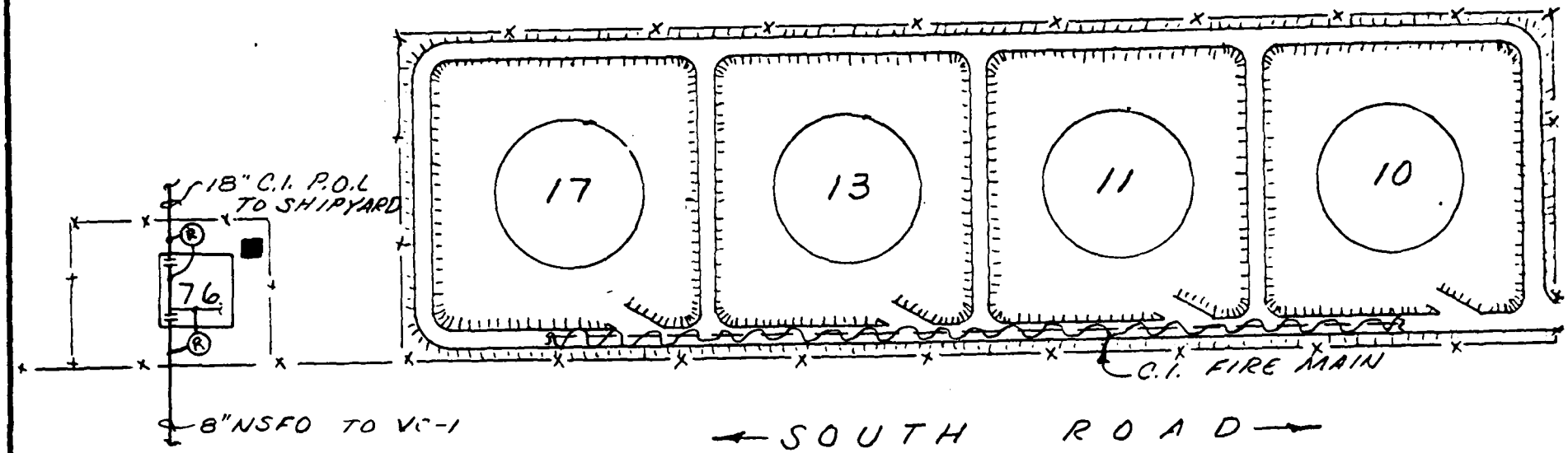
●#1 SOIL RESISTIVITY LOCATION

(1)→ PIPE-TO-SOIL POTENTIAL LOCATION

CT#1 CURRENT TEST LOCATION

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: C-4
DRAWN: R.E.F.	DATE: 2-16-82
APPROVED: H.F.S.	NUMBER: 6508



-496-

LOWER TANK FARM

N

SCALE: NONE

LEGEND

- INSTALL NEW INSULATING FLANGE SETS AND INSTALL NEW RESISTANCE BOND STA.
- CONTINUITY BOND ACROSS EACH JOINT OF CAST IRON FIRE MAIN
- INSTALL A NEW OIL COOLED RECTIFIER AND INSTALL GRAPHITE ANODES

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: C-4
DRAWN: R. E. F.	DATE: 2-16-82
APPROVED: H. T. S.	NUMBER: 6508 A

SECTION C-5

THIS SECTION INCLUDES ONE OUTDOOR BALLAST TANK AND ONE WATER STORAGE TANK AT THE STILLING BASIN AND ASSOCIATED PIPING

SECTION C-5

SUMMARY

1. Conclusions:

Based on the field data obtained, the following results were observed:

A. Ballast Tank #355 at Adit #6:

(1) The soil environment in this tank site can be classified as an area of severe corrosion potential.

(2) The results of the "As Found" potentials indicate that the external bottom surface area of Tank #355 and the 4" under ground line from Tank #355 to the Pump Station are not receiving any cathodic protection with all readings below -500 mv.

(3) Tank #355 and and the 4" line from Tank #355 to the Pump Station were found to be electrically discontinuous with the POL lines of Section A-1.

(4) Approximately 1,000 sq. ft. of coated steel is to be considered for cathodic protection. Approximately 1.5 amperes D.C. will be required to accomplish this achievement.

B. Fresh Water Storage Tank at Adit #3:

(1) The soil environment in this tank site can be classified as an area of severe corrosion potential.

(2) There were no insulators found installed on the water piping system.

(3) The fresh water storage tank and associated piping were found to be electrically continuous with the POL lines of Section A-1.

(4) The results of "As Found" potentials indicate the internal wetted tank surface area, the external bottom surface and the underground water lines were not cathodically protected at the time of this survey.

(5) Approximately 3.3 amperes D.C. and 10 amperes D.C. will be required

to provide protection for the internal wetted tank surface and the external bottom surface area and the underground water pipelines, respectively.

(6) The coating on the tank roof, stairway and the above ground lines was inspected. Rusting and corrosion have taken place in the areas where the paint coating was damaged and/or deteriorated.

(7) The existing magnesium anodes, which were installed around the tank, were found to have deteriorated to a point beyond their useful life.

2. Recommendations:

A. Ballast Tank #555 at Adit #6:

(1) It is recommended that a new impressed current system be installed to provide protection for the external bottom surface area and the 4" line from Tank #355 to the Pump Station. This system will also provide partial protective current for the 16" JP-5 line of Section A-1, as mentioned in Section A-1.

(2) A resistance bond station should be installed at the existing insulator on the 8" sludge line near Tank #355.

B. Fresh Water Storage Tank at Adit #3:

(1) It is recommended that a new impressed current system be installed to provide protection for the external tank bottom surface area and the underground water pipeline. The recommended system will consist of one oil cooled rectifier and ten (10) 4"x40" graphite anodes. The new anode bed should be installed in the area adjacent to the tank and the Stilling Basin.

(2) A resistance bond station should be installed between the 16" JP-5 line of Section A-1 and the 10" fresh water line near the manhole at Adit #3.

(3) It is recommended that the existing five, 17 lb. magnesium anodes be replaced with five, 4"x4"x60" - 60 lb. magnesium anodes. This system will provide protection for the internal wetted surface

area.

(4) It is recommended that the damaged coating areas of the tank structure be repaired as soon as possible.

SECTION C-5

THIS SECTION INCLUDES ONE OUTDOOR BALLAST TANK AND ONE WATER STORAGE TANK AT THE STILLING BASIN AND ASSOCIATED PIPING

1. Description.

A. Structures to be Protected:

(1) Ballast Tank #355 at Adit #6

a. External bottom surface area of tank.

b. 4" Coat steel line from Tank #355 to Pump Station.

(2) Water Storage Tank at Adit #6

a. External bottom surface area of tank.

b. Internal bottom surface area of tank.

c. 10" over flow line from tank to Stilling Basin - Coated Steel

d. 10" line from tank to Stilling Basin - Coated Steel

e. 4" line from tank to Stilling Basin - Coated Steel

f. 10" fresh water line from Pump Station to MH - Coated Steel

B. Existing Cathodic Protection System:

(1) Ballast Tank #355 at Adit #6

No cathodic protection system was found installed for this section during this survey.

(2) Water Storage Tank at Adit #3

A study of NAVFAC Drawings 1311790 to 1311794 revealed that the external bottom surface area of this tank was originally designed to be protected by three 32 lb.

prepackaged magnesium anodes. The internal wetted surface areas of the tank were originally designed to be protected by five 17 lb. magnesium anodes. The anode open circuit potential and the current output measurements were made at the existing anode that is near the drain manhole of the tank. The results are as follows:

a. Anode open circuit potential - -1540 mv.

   A primary magnesium anode should have an anode open circuit of more than -1600 mv with respect to a copper-copper sulphate reference electrode. It is evident that this anode installed was a secondary anode.

b. Anode current output - 34 ma.

   A 32 lb. prepackaged magnesium anode installed in 2000 ohm-cms soil should have a minimum current output of more than 150 ma. This indicates that this anode has deteriorated to a point beyond its useful service life.

No measurements were made on the existing 17 lb. prepackaged magnesium anodes installed inside the water storage tank because these anodes were suspended with the anode leads directly connected to the internal tank structure.

2. Field Work and Evaluation of Data.

   A. Soil Resistivity Measurements: A total of five sets of soil resistivity measurements were obtained around these tanks as shown in Table No. XX-A. The results of these

measurements have been classified into various categories of corrosiveness as shown in the following table:

Resistivity Category	Range (ohm-cms)	Approximate Percentage of Readings		Anticipated Corrosion
		Tank #355	Water Tank	
Low	0 - 2,000	83	55	Severe
Medium	2,000 - 10,000	17	45	Moderate
High	10,000 - 30,000	0	0	Slight unless other factors are pronounced
Very High	Above - 30,000	0	0	Normally non-corrosive

The low resistivity indicates a severe corrosion condition on the exterior bottom area of the metallic storage tanks. Of the measurements obtained on Tank #355, 83% of these measurements were in the severe category and on the water tank, 55% of the measurements were also in the severe category and 17% of the measurements obtained on the Tank #355 and 45% of the measurements obtained on the water tank were in the medium or moderate category.

B. "As Found" Structure-to-Soil and/or Tank-to-Water Potentials:

(1) "As Found" Structure-to-Soil Potentials: "As Found" structure-to-soil potentials were obtained at each side of the tanks and at the representative locations on the associated piping. The results of these measurements indicated that the external bottom surface

areas of Tank #355 and the external bottom surface of the water tank and the underground lines around these tanks are not at a protective potential level. The results of these measurements are shown in Table No. XX-B.

(2) "As Found" Tank-to-Water Potentials: "As Found" tank-to-water potentials were obtained inside the water storage tank with a copper-copper sulphate reference electrode submerged at 2' intervals in a vertical line from the bottom of the water storage tank to 6" below the water level. The results of these measurements indicated that the internal wetted surface area of this tank is not at a protective potential level, with all readings less negative than -750 mv. The results of these measurements are also shown in Table No. XX-B.

C. Current Tests:

(1) Ballast Tank #355: During this survey, two current tests were conducted in the area near Tank #355. During each test, the tank and/or pipe-to-soil potentials were obtained at each side of the tank and the 4" line at the Pump Station with the test rectifier "off" and "on".

a. Current Test No. 1 - This current test was conducted in the area east of Tank #355. Six steel rods were installed 40' east of Tank #355 as a test anode bed. The negative from a test rectifier was connected to the tank. The current used for this test was 1.5 amperes D.C.. The results

of this test are shown in Table No. XX-C.

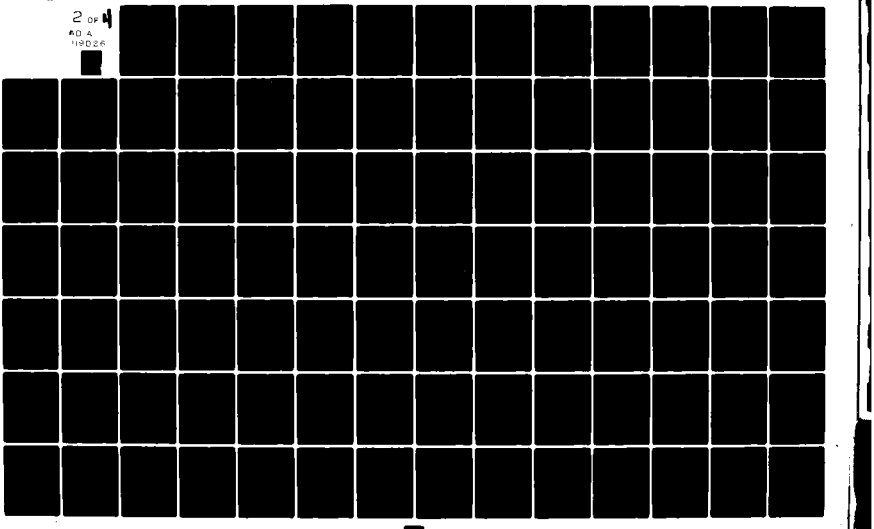
b. Current Test No. 2 - This current test was conducted with the same anode configuration and negative connection as Current Test No. 1. The current was increased to 2 amperes D.C.. The results of this test are shown in Table No. XX-D.

(2) Fresh Water Storage Tank: A total of three current tests were conducted. During each test, structure-to-soil and/or tank-to-water potentials were obtained at the same locations as "As Found" potentials with the test rectifier "off" and "on".

a. Current Test No. 3 - This current test was conducted in the area west of the water tank. Seven steel rods were installed between the tank and the Stilling Basin as a temporary anode bed. The negative from a test rectifier was connected to the tank. The current used for this test was 8 amperes D.C.. The results of this test are shown in Table No. XX-3.

b. Current Test No. 4 - This test was conducted inside the water storage tank. One 2"x60" high silicon iron anode was submerged below the water level inside the water tank as a test anode. The negative from a test rectifier was connected to the water tank. The current used for this test was 3.3 amperes D.C.. The results of this test are shown in Table No. XX-F.

AD-A119 026 PACIFIC CORROSION RESEARCH INC HUNTINGTON BEACH CA F/G 13/8
A-E SERVICES TO PERFORM A CATHODIC PROTECTION SURVEY OF THE BUL--ETC(U)
JUN 82 N62742-81-C-0006
UNCLASSIFIED NL



c. Current Test No. 5 - This current test was conducted with the same anode configuration and the negative connection as Current Test No. 4. The current used for this test was increased to 6.6 amperes D.C.. The results of this test are shown in Table No. XX-G.

Based on the data obtained from these tests, the following conclusions are submitted:

Tank #355 at Adit #6:

i. Ballast Tank #355 was found to be electrically discontinuous with the POL lines of Section A-1.

ii. The 8" sludge line from Tank #355 to Adit #6 was isolated with an insulating flange above ground at the tank.

iii. The fire line is not electrically continuous with Ballast Tank #355.

iv. The external bottom surface area of Tank #355 and the 4" line from Tank #355 to the Pump Station are not receiving any protection. To have the external bottom surface area and the 4" underground line under cathodic protection, it will require 1.5 amperes D.C. as indicated in Current Test No. 1.

Fresh Water Storage Tank At Adit #3

i. The external tank bottom and the internal tank wetted surface areas are not at a protective potential level.

ii. No insulators were found to be installed on the metallic lines at the tank and in the manhole near Adit #3.

iii. The water storage tank and associated line were found to be electrically continuous with the 16" JP-5 line of Section A-1.

iv. For protection of the external tank bottom area and the underground associated metallic lines, it will require 10 amperes D.C. as indicated by Current Test No. 3. For protection of the internal wetted tank surface area, it will require 3.3 amperes D.C. as indicated by Current Test No. 4.

D. Inspection of Tank and Lines:

(1) The coating of the Ballast Tank #355 and the 8" sludge lines were inspected and found to be in good condition.

(2) The external coating of the fresh water storage tank structure was inspected on December 3, 1981. Rusting and corrosion have taken place in some areas where coating was damaged and/or had deteriorated.

E. Leak History: We were advised by Base Fuel Personnel that no leaks had been records in the past.

3. Conclusions.

Based on the field data obtained, the following results were observed:

A. Ballast Tank #355 at Adit #6:

(1) Soil resistivity measurements indicate that 83% of the readings are in the severe category and 17% are in the

moderate category. The environment in this tank site can be classified as an area of severe corrosion potential.

(2) The results of the "As Found" potentials indicate that the external bottom surface area of Tank #355 and the 4" under ground line from Tank #355 to the Pump Station are not receiving any cathodic protection with all readings below -500 mv.

(3) Tank #355 and the 4" line from Tank #355 to the Pump Station were found to be electrically discontinuous with the POL lines of Section A-1.

(4) The results of the current tests conducted indicated the current demand for the external tank bottom and the 4" line protection will not be high. Approximately 1,000 sq. ft. of coated steel is to be considered for cathodic protection. Approximately 1.5 amperes D.C. will be required to accomplish this achievement.

B. Fresh Water Storage Tank at Adit #3:

(1) Soil resistivity measurements indicated that 55% of the readings are in the severe category and 45% are in the moderate category. The environment in this tank site can be classified as an area of severe corrosion potential.

(2) There were no insulators found installed on the water piping system.

(3) The fresh water storage tank and associated piping were found to be electrically continuous with the POL

lines of Section A-1.

(4) The results of "As Found" potentials indicate that the internal wetted tank surface area, the external tank bottom surface area and the underground water lines were not cathodically protected at the time of this survey.

(5) The results of the current tests conducted indicated the current demand will be moderate. Approximately 3.3 amperes D.C. and 10 amperes D.C. will be required to provide protection for the internal wetted tank surface and the external tank bottom surface area and the underground water pipelines.

(6) The coating on the tank roof, stairway and the above ground lines was inspected. Rusting and corrosion have taken place in the surface areas where the paint coating was damaged and/or deteriorated.

(7) The existing magnesium anodes, which were installed around the tank, were found to be deteriorated to a point beyond their useful life.

4. Recommendations.

A. Ballast Tank #355 at Adit #6:

(1) From the results of the field tests, it is recommended that a new impressed current system be installed to provide protection for the external tank bottom surface area and the 4" line from Tank #355 to the Pump Station. This system will also provide partial protective current for the 16" JP-5 line of Section A-1 as mentioned in Section A-1. This recommended system will consist

of one oil cooled rectifier, ten 4½"x60" high silicon iron anodes and an anode watering system. The anode bed should be installed in the area adjacent to Tank #355.

(2) A resistance bond station should be installed at the existing insulator on the 8" sludge line near Tank #355.

B. Fresh Water Storage Tank at Adit #3:

(1) It is recommended that new impressed current system be installed to provide protection for the external tank bottom surface area and the underground water pipeline. The recommended system will consist of one oil cooled rectifier, ten 4"x40" graphite anodes and an anode watering system. The new anode bed should be installed in the area adjacent to the tank and the Stilling Basin.

(2) A resistance bond station should be installed between the 16" JP-5 line of Section A-1 and the 10" fresh water line near the manhole at Adit #3.

(3) It is recommended that the existing five 17 lb. magnesium anodes be replaced with five 4"x4"x60", 60 lb. magnesium anodes. This system will provide protection for the internal wetted surface area.

(4) It is recommended that the damaged coating areas of the tank structure be repaired as soon as possible.

NOTE: The locations of the pipe-to-soil potentials, soil resistivities, current tests and the existing C.P. systems are shown on PCR Drawing No. 6509.

The recommended C.P. system for Section C-5 is shown on PCR Drawing No. 6509-A.

NAVFAC 1613/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 1 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-5

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
OIL COOLED RECTIFIER	2	ea	1950.00	3900.00	600.00	1200.00	2550.00	5100.00
4½" X 60" HI SILICON IRON ANODES	10	ea	720.00	7200.00	150.00	1500.00	870.00	8700.00
4" X 40" GRAPHITE ANODES	10	ea	210.00	2100.00	150.00	1500.00	360.00	3600.00
4" X 4" X 60"-60lb. MAGNESIUM ANODES	5	ea	225.00	1125.00	150.00	750.00	375.00	1875.00
COAL COKE BREEZE	7500	lb	0.30	2250.00	0.07	525.00	0.37	2775.00
RESISTANCE BOND STATION	2	ea	150.00	300.00	150.00	300.00	300.00	600.00
CONCRETE PAD	2	ea	150.00	300.00	600.00	1200.00	750.00	1500.00
#2 HMP STRANDED COPPER CABLE	800	ft	1.50	1200.00	0.15	120.00	1.65	1320.00
1" PVC CLASS 200 PLASTIC PIPE	1100	ft	0.75	825.00	0.15	165.00	0.90	990.00
HOSE CONNECTION ADAPTERS	2	ea	7.50	15.00	7.50	15.00	15.00	30.00
SPLIT BOLTS	25	ea	1.05	26.25	4.50	112.50	5.55	138.75
ALUMINO-THERMIC WELDS	10	ea	3.00	30.00	37.50	375.00	40.50	405.00
COAL TAR ENAMEL (1 GALLON CAN)	1	ea	22.50	22.50	45.00	45.00	67.50	67.50
BUTYL TAPE	3	rl	37.50	112.50	45.00	135.00	82.50	247.50
RUBBER TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
PLASTIC TAPE	9	rl	4.50	40.50	7.50	67.50	12.00	108.00
ANODE HAND HOLE	5	ea	75.00	375.00	150.00	750.00	225.00	1125.00

S/N 0105-LF-010-1335

NAVFAC 11013/7 (1-78)
Supersedes NAVDOCKS 2417 and 2417A

COST ESTIMATE

DATE PREPARED: Feb. 5, 1982

SHEET 2 OF 2

ACTIVITY AND LOCATION: BULK FUEL TERMINALS, NSC
PEARL HARBOR, HAWAII

CONSTRUCTION CONTRACT NO: N62742-81-R-0006

IDENTIFICATION NUMBER:

PROJECT TITLE: CATHODIC PROTECTION SYSTEM
CORROSION SURVEY, SECTION C-5

ESTIMATED BY: H. TSO

CATEGORY CODE NUMBER:

STATUS OF DESIGN: ☐ PED ☒ 30% ☐ 100% ☐ FINAL ☐ Other (Specify) _____

JOB ORDER NUMBER:

ITEM DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
ANODE SUPPORTS	5	ea	30.00	150.00	75.00	375.00	105.00	525.00
TERRA TAPE	600	ft	0.23	138.00	0.07	42.00	0.30	180.00
TRENCH	600	ft	-	-	4.50	2700.00	4.50	2700.00
SUBTOTAL				20150.25		11944.50		32094.75
10% MATERIALS & LABOR				2015.00		1194.00		3209.00
SUBTOTAL				22165.25		13138.50		35303.75
30% CONSTRUCTION PROFIT				6649.57		3941.55		10591.12
TOTAL				28814.82		17080.05		45894.87

S/N 0105-LF-010-1335

* G.P.O. 1978 [illegible] 016/4302

SECTION C-5

SOIL RESISTIVITIES

TABLE NO. XX-A

Rdg. No.	Location	Soil Resistivities (ohm-cms) Depth 2.5'	5'	10'
1.	Water Tank at the Stilling Basin			
	10' W. of Tank	1200	2400	2000
	100' W. of Tank	2000	2600	2400
	S. of VC near Adit 3	2950	1900	880
2.	Ballast Tank 355			
	E. of Tank	340	340	200
	W. of Tank	4300	880	280

SECTION C-5

"AS FOUND" STRUCTURE-TO-SOIL AND/OR TANK-TO-WATER

POTENTIAL MEASUREMENTS

TABLE NO. XX-B

Rdg. No.	Location	Structure-to-Soil Potentials or Tank-to-Water Potentials (mv)
1.	Ballast Tank 355	
	N. side	-460
	E. side	-450
	S. side	-450
	W. side	-480
	4" line at Pump Station	-450
2.	Water Tank at the Stilling Basin	
	1. Exterior Protection	
	W. side	-480
	N. side	-490
	E. side	-500
	S. side	-560
	Water line at VC near Adit 3	-470
	Sludge line at VC near Adit 3	-470
	2. Internal Protection (Water Level 13')	
	Bottom of Tank	-660
	2' from Bottom	-680
	4' from Bottom	-700
	6' from Bottom	-725
	8' from Bottom	-730

10' from Bottom	-735
12' from Bottom Surface	-740

SECTION C-5

CURRENT TEST NO. 1

TABLE NO. XX-C

Location: Ballast Tank 355.

Anodes used for current test: Six steel rods were used as temporary anodes.

Negative connection: To Tank.

Rectifier D.C. Output: 1.5 amperes D.C.

Rdg. No.	Location	Structure-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	N. side of Tank	-460	-1240	780
2.	E. side of Tank	-450	-1330	880
3.	S. side of Tank	-450	-1260	810
4.	W. side of Tank	-480	-1200	720
5.	Water line S. of Tank	-410	-380	-30*
6.	Tank side of Insulator	-450	-1260	810
7.	Ground side of Insulator	-595	-560	-35*
8.	4" line at Pump Station	-480	-1200	720

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION C-5

CURRENT TEST NO. 2

TABLE NO. XX-D

Location: Ballast Tank 355.

Anodes used for current test: Six steel rods were used as temporary anodes.

Negative connection: To Tank.

Rectifier D.C. Output: 2 amperes D.C.

Rdg. No.	Location	Structure-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	N. Side of Tank	-500	-1450	950
2.	E. side of Tank	-450	-1520	1070
3.	S. side of Tank	-495	-1430	935
4.	W. side of Tank	-500	-1520	1020
5.	Water line S. of Tank	-410	-350	-60*
6.	Tank side of Insulator	-495	-1430	935
7.	Ground side of Insulator	-600	-560	-40*
8.	4" line at Pump Station	-500	-1520	1020

*A minus change indicates that the pipe-to-soil potential became less negative as a result of application of test current.

SECTION C-5

CURRENT TEST NO. 3

TABLE NO. XX-E

Location: Water tank at Stilling Basin.

Anodes used for current test: Seven steel rods were used as temporary anodes.

Negative Connection: To Tank.

Rectifier D.C. Output: 8 amperes D.C.

Rdg. No.	Location	Structure-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	W. side of Tank	-560	-1600	1040
2.	N. side of Tank	-480	-960	480
3.	E. side of Tank	-490	-1100	610
4.	S. side of Tank	-500	-1280	780
5.	At Pump Station	-510	-960	450
6.	Water line in MH near Adit 3	-470	-660	190
7.	Sludge line in MH near Adit 3	-470	-660	190

SECTION C-5

CURRENT TEST NO. 4

TABLE NO. XX-F

Location: Water Tank internal surface at Stilling Basin.

Anodes used for current test: One 2"x60" high silicon iron anode.

Negative Connection: To Tank.

Rectifier D.C. Output: 3.3 amperes D.C.

Rdg. No.	Location	Structure-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bottom of the Tank	-660	-790	130
2.	2' from Bottom	-680	-760	80
3.	4' from Bottom	-700	-780	80
4.	6' from Bottom	-725	-900	175
5.	8' from Bottom	-730	-1220	490
6.	10' from Bottom	-735	-1190	455
7.	12' from Bottom	-735	-1300	565
8.	Surface	-740	-1320	580

SECTION C-5

CURRENT TEST NO. 5

TABLE NO. XX-G

Location: Water tank internal surface at Stilling Basin.

Anodes used for current test: One 2"x60" high silicon iron anode.

Negative Connection: To Tank.

Rectifier D.C. Output: 6.5 amperes D.C.

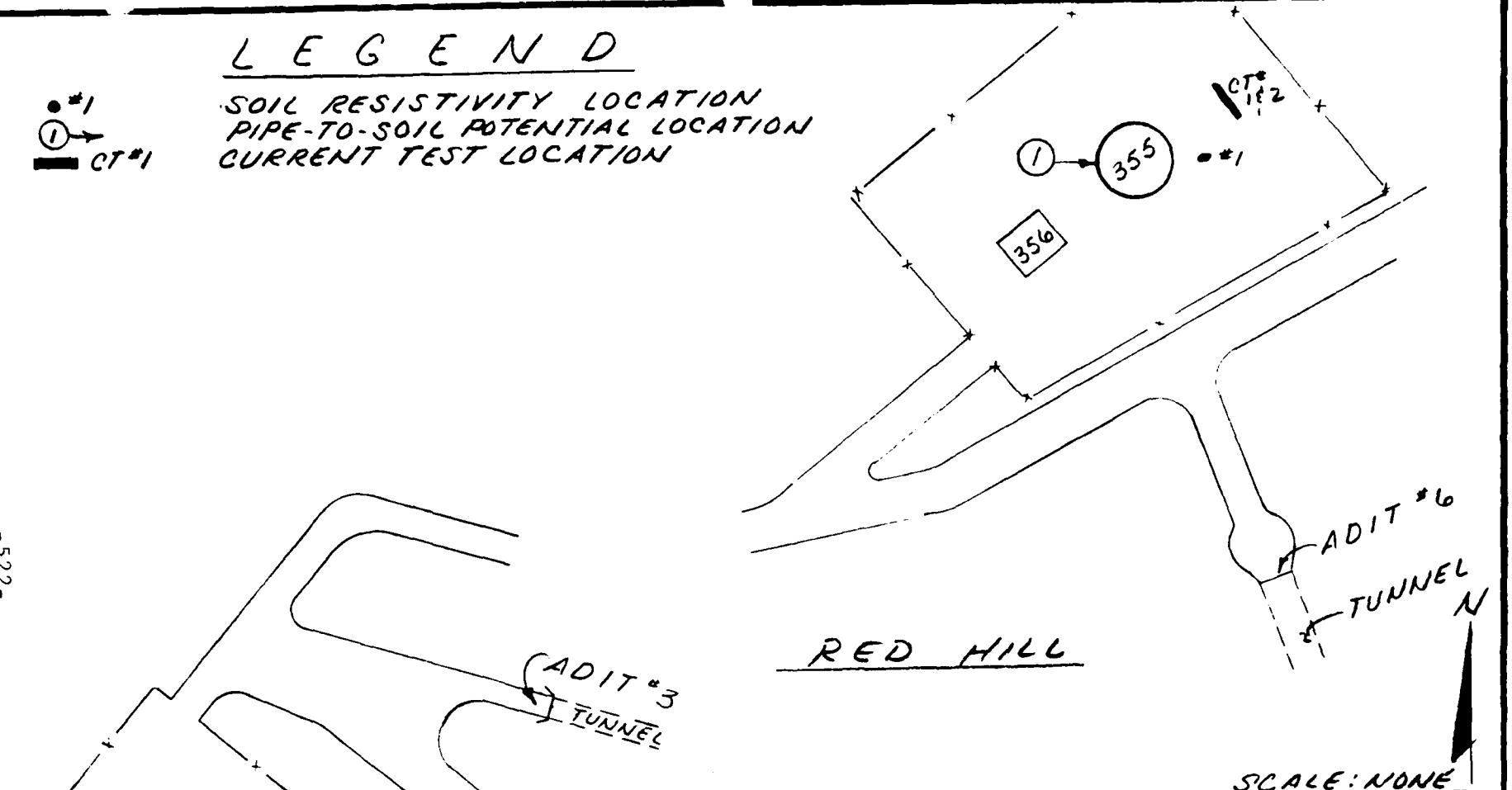
Rdg. No.	Location	Tank-to-Soil Potentials (mv) I(Off)	I(On)	Change
1.	Bottom of Tank	-660	-870	210
2.	2' from Bottom	-680	-1060	380
3.	4' from Bottom	-700	-1500	800
4.	6' from Bottom	-725	-1720	995
5.	8' from Bottom	-730	-2000	1270
6.	10' from Bottom	-735	-1900	1165
7.	12' from Bottom	-735	-2000	1265
8.	Surface	-740	-2080	1340

LEGEND

●#1 SOIL RESISTIVITY LOCATION

①→ PIPE-TO-SOIL POTENTIAL LOCATION

▬ CT#1 CURRENT TEST LOCATION



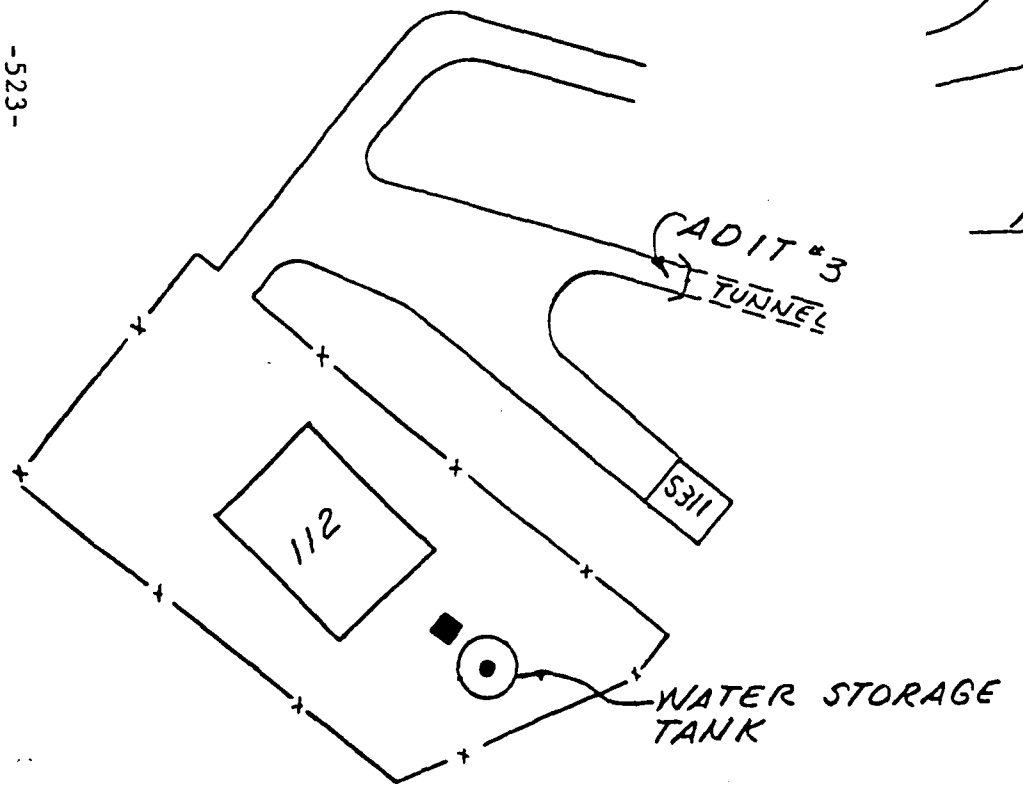
SCALE: NONE

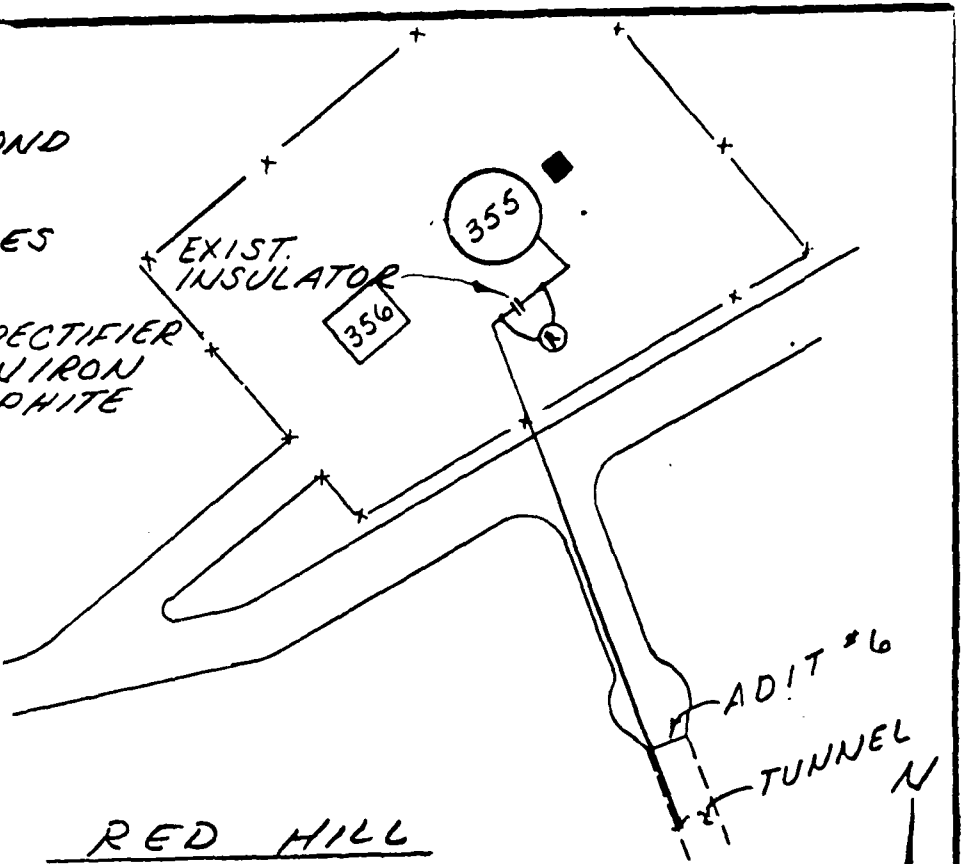
-522-

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: C-5
DRAWN: REF.	DATE: 2-16-62
APPROVED: HTJO	NUMBER: 6509

LEGEND

- INSTALL NEW RESISTANCE BOND STATION
- INSTALL MAGNESIUM ANODES INSIDE TANK
- INSTALL A NEW OIL COOLED RECTIFIER AND INSTALL HIGH SILICON IRON TUBULAR ANODES OR GRAPHITE ANODES.





RED HILL

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
PROPOSED C.P. SYS.	SECTION: C-5
DRAWN: R.E.F.	DATE: 2-16-82
APPROVED: H.F.S.	NUMBER: 6509-A

SECTION E-1

EXISTING IMPRESSED CURRENT TYPE OF CATHODIC PROTECTION SYSTEM

SECTION E-1

SUMMARY

Summary

It is recommended that existing Rectifiers #3, #5, #8, #9, #11, #12 and #13 be replaced with oil cooled rectifiers. The existing anode beds of these rectifiers should be replaced with thirty-six (36) 4"x40" graphite anodes, ten (10) 4"x80" graphite anodes, ten (10) 4½"x60" high silicon iron anodes and twenty (20) 4 3/4"x84" high silicon iron tubular anodes.

It is our professional opinion that air cooled rectifiers are generally used for underground structures and/or pipeline applications in areas of dry atmospheres and free of dust. The primary use of oil cooled rectifiers is in the areas i.e. islands, or other marine or industrial environments, where the atmosphere is very corrosive. Oil cooled rectifiers will provide as much longer service life. For locations subject to explosion hazards, such as in Fuel Tank Farms, Fuel Loading Facilities and valve pits, an oil cooled rectifier with explosion proof fittings and housing should be used. It is recommended that oil cooled rectifiers be used in all future designs for this facility.

SECTION E-1

EXISTING IMPRESSED CURRENT TYPE OF CATHODIC PROTECTION SYSTEM

1. Description.

In reviewing the "Map showing cathodic protection systems of the POL lines", (Y & D Drawing No. 959780) revealed that there were twenty-four (24) rectifiers originally installed to protect the Navy, Air Force and Standard Oil Company owned lines in Pearl Harbor and adjacent areas. The rectifiers and associated anode beds are shown in the following list:

NAVY Designated Rectifier No.	Dwg. No.	Title	Present Status
R-1	Y & D 475501	C.P. on Facilities for gasoline piping	Maintained by U.S. Air Force
R-2	Y & D 475502	C.P. on Facilities for gasoline piping	Maintained by Standard Oil Co.
R-3	Y & D 475503	C.P. on Facilities for gasoline piping	Maintained by Fuel Dept., NSC
R-4	Y & D 475504	C.P. on Facilities for gasoline piping	Maintained by U.S. Air Force
R-5	Y & D 475504 Y & D 475509 Y & D 515711	C.P. on Facilities for gasoline piping C.P. General Layout	Maintained by Fuel Dept., NSC
R-6	Y & D 475505 PWCEN N26-988	C.P. on Facilities for gasoline piping	Maintained by U.S. Air Force
R-7	Y & D 475506 PWCEN N26-989	C.P. on Facilities for gasoline piping	Maintained by U.S. Air Force
R-8	Y & D 482986	C.P. Facilities NSC Area	Maintained by Fuel Dept., NSC
R-9	No Dwg. Available		
R-10	Y & D 709302	C.P. for the Dock Area, Keehi Lagoon	Maintained by U.S. Air Force

R-11	Y & D 515711	C.P. General Lay-out and Details	Maintained by Fuel Dept., NSC
	Y & D 890501	Conversion of POL Storage Facilities, C.P.	Maintained by Fuel Dept., NSC
R-12	Y & D 890501	Conversion of POL Storage Facilities, C.P.	Maintained by Fuel Dept., NSC
R-13	Y & D 890501	Conversion of POL Storage Facilities, C.P.	Maintained by Fuel Dept., NSC
R-1(F)	Ford Island PWD V-N24-171	C.P. Facilties, Fuel Lines, General Layout	Maintained by Fuel Dept., NAS, Ford Island
R-2(F)	Ford Island PWD V-N24-171	C.P. Facilities, Fuel Lines, General Layout	Maintained by Fuel Dept., NAS, Ford Island
R-3(F)	Ford Island PWD V-N24-171	C.P. Facilities, Fuel Lines, General Layout	Maintained by Fuel Dept., NAS, Ford Island
R-4(F)	Y & D 872777	C.P. Ferry Slip "A" & Berth F-3½	Maintained by Fuel Dept., NAS, Ford Island
R-A	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-B	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-C	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-D	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-E	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-F	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force

R-G	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-H	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force
R-J	Hickam Air Force Base NOR 100/136	Basic Layout Plan	Maintained by U.S. Air Force

2. Rectifiers and Associated Anode Beds.

As can be seen from the above list, only Rectifiers #3, 5, 8, 9, 11, 12 and 13 are now being maintained by the Fuel Department, Naval Supply Center. During this survey each of these rectifiers and anode beds were checked. The results are as follows:

A. Rectifier #3 - Oil Cooled

(1) Rectifier Location: - Rectifier #3 is located south of Building 691 and between Victor Docks #1 and #2.

(2) Rectifier Unit: - Mfg. - Electrical Facilities, Inc.
Serial No. - 5033571
D.C. Capacity - 8 V, 50 A
Operating at - Tap setting 5-4
D.C. Output - 3.5 V, 43 A
Date Recorded - Oct. 10, 1981

(3) Anode Bed Location: - Two sections of railroad tracks installed approximately 30' south of the shore line.

(4) POL Lines to be Protected by Rectifier #3:

a. Section A-2 - The POL lines in the area adjacent to the Pearl City Tank Farm are not at a protective potential level, but the POL lines north of Victor Docks are cathodically protected.

b. Section A-3 - This section of POL lines are cathodically protected.

(5) Recommendations:

The existing anode bed consisting of two sections of railroad tracks should be replaced with ten 4 3/4"x84" high silicon iron tubular anodes and a new oil cooled rectifier, as recommended in Section A-5.

B. Rectifier #5 - Oil Cooled:

(1) Rectifier Location: - This rectifier is located south side of the bridge near Gate #3, NAS, Barbers Point.

(2) Rectifier Unit: - Mfg. - Electrical Facilities, Inc.
Serial No. - Unknown (no name plate)
D.C. Capacity - 50 V, 50 A
Operating at - Tap setting 2-7
D.C. Output - 42 V, 0 A
Date Recorded - Dec. 5, 1981

(3) Anode Bed Location: - This anode bed was installed 500' south of the rectifier and perpendicular to the

8" JP-5 line.

During this survey, Rectifier #5 was found not in operation. The underground anode header cable, on the east side of the stream, was found to be torn out recently by construction work to clear out the debris from the stream.

(4) POL Lines to be Protected by Rectifier #5:

a. Section A-4 - The POL lines of Section A-4 are not at a protective potential level.

b. POL Line, NAS, Barbers Point - A portion of the POL lines in the area adjacent to Gate #3, Barbers Point, are not at a protective potential level.

(5) Recommendations:

The existing anode bed of Rectifier #5 was not installed within the easement of the 8" JP-5 line and/or on the Government property. During this survey, the anode header cable was found to be severely damaged by construction work done to clear the debris out of the stream. This damaged anode bed should be replaced with ten 4"x40" graphite anodes, a new oil cooled rectifier and an anode watering system, as recommended in Section A-4.

C. Rectifier #8 - Oil Cooled:

(1) Rectifier Location: - Rectifier #8 is located on the west side of VC-2 near Halawa Gate.

(2) Rectifier Unit: - Mfg. - Brance Kraghy Co., Inc.
Serial No. - 753122

D.C. Capacity - 30 V, 150 A
Operating at - Tap setting 4-7
D.C. Output - 18 V, 140 A
Date Recorded - Aug. 18, 1981

(3) Anode Bed Location: - Two junk diesel engine blocks were installed approximately 200' south of VC-2 and 50' west of the POL lines.

(4) POL Lines to be Protected by Rectifier #8:

The POL lines of Section B-1, B-2, B-3, B-5 and a portion of Section B-6 were to be protected by Rectifier #8. The results of "As Found" pipe-to-soil potentials indicate that these POL lines are not at a protective potential level.

(5) Recommendations:

Rectifier #8 was found to be operating at 18 volts and 140 amperes D.C. during this survey. The protective current has been provided by two large engine blocks which were installed 20' deep and approximately 20' apart. This amount of protective current to the protected lines has been reduced to 50% of its effectiveness because of current bucking. This is the result of engine blocks being installed in close proximity to each other. This anode bed should be replaced with fourteen 4"x40" graphite anodes, a new oil cooled rectifier and an anode watering system, as recommended in Section B-1.

D. Rectifier #9 - Air Cooled:

(1) Rectifier Location: - Rectifier #9 is located on the west side of Building 553.

(2) Rectifier Unit: - Mfg. - Goodall
Serial No. - 79C1380
D.C. Capacity - 40 V, 80 A
Operating at - Tap setting 4-5
D.C. Output - 50 V, 9 A
Date Recorded - Aug. 24, 1981

(3) Anode Bed Location: - Nine 3"x60" graphite anodes were installed south of Building 229 in 1979.

(4) POL Lines to be Protected by Rectifier #9:
The POL lines of Section B-4, B-6, B-7 and C-3 were to be protected by this rectifier. The results of "As Found" pipe-to-soil potentials indicate that this rectifier does not provide adequate protective current for these lines.

(5) Recommendations:
Existing Rectifier #9 was originally installed south-west of Tank #36 (S748) at the Middle Tank Farm. The anode header cable was checked and found to be broken under the parking area near the rectifier location. A new rectifier (#9) with nine 3"x60" graphite anodes were installed south of Building 229, by Mr. John Kimi and his staff in 1979. The capacity of Rectifier #9

is 40 volts and 80 amperes. This rectifier was checked and operated above its maximum D.C. output with a tap setting of 4 (coarse) - 5 (fine), 50 volts and 9 amperes D.C.. The D.C. output of this rectifier can not be adjusted to a higher current output due to the following reasons:

a. Lack of D.C. voltage capacity.

b. Inadequate number of anodes.

c. Anodes installed in a high resistivity environment or installed in sand and/or in dry soil.

Therefore, Rectifier #9 does not and cannot provide adequate protective current for the POL lines of Sections B-4, B-6, B-7 and C-3. The existing anode bed of Rectifier #9 should be replaced with twelve 4"x40" graphite anodes, a new oil cooled rectifier and an anode watering system, as recommended in Section C-3.

E. Rectifier #11 - Oil Cooled:

(1) Rectifier Location: - Rectifier #11 is located southwest of the Pearl City Tank Farm.

(2) Rectifier Unit: - Mfg. - Electrical Facilities, Inc.
Serial No. - Unknown (no name plate)
D.C. Capacity - 20 V, 50 A
Operating at - Tap setting 5-4
D.C. Output - 3.5 V, 13 A
Date Recorded - Oct. 10, 1981

(3) Anode Bed Location: - Three sections of railroad track were installed 5' east of Kalapo Canal and approximately 350' north of Waipuna Avenue.

(4) POL Lines to be Protected by Rectifier #11:

The external tank bottom surface areas of Section C-1, the POL lines of Section A-5 and a portion of the POL lines of Section A-2 were to be protected by this rectifier. The results of "As Found" pipe-to-soil potentials indicate that these tanks and POL lines are not at a protective potential level.

The existing anode bed of Rectifier #11 should be replaced with fourteen 4½"x60" high silicon iron anodes and a new oil cooled rectifier, as recommended in Section A05.

F. Rectifier #12 - Air Cooled:

(1) Rectifier Location: - Rectifier #12 is located in the Pearl Harbor Park.

(2) Rectifier Unit: - Mfg. - Goodall
Serial No. - CAWSC 28-46
D.C. Capacity - 28 V, 46 A
Operating at - Tap setting 2-3
D.C. Output - 10 V, 0 A
Date Recorded - Oct. 10, 1981

(3) Anode Bed Location: - This anode bed consists of an unknown number and type

of anodes placed on the sea floor, south of the existing Rectifier #12.

(4) POL Lines to be Protected by Rectifier #12:

The POL lines from Aloha Stadium to Pearl City Tank Farm, of Section A-1, were to be protected by this rectifier. The results of "As Found" pipe-to-soil potentials indicated that the POL lines of Section A-1 are not receiving full protection.

(5) Recommendations:

During this survey, existing Rectifier #12 was found not in operation. A break in the anode header cable was found near the tidal level south of Rectifier #12. This existing anode bed should be replaced with ten 4½"x60" high silicon iron anodes and a new oil cooled rectifier, as recommended in Section A-1.

G. Rectifier #13 - Air Cooled:

(1) Rectifier Location: - Rectifier #13 is located east of VC-40 and north of H3 Freeway.

(2) Rectifier Unit: - Mfg. - Goodall
Serial No. - Unknown
D.C. Capacity - 28 V, 46 A
Operating at - Tap setting C-5
D.C. Output - 10 V, 9.5 A
Date Recorded - Oct. 11, 1981

(3) Anode Bed Location: - This anode bed consists of an unknown number of graphite

anodes installed on the south side of H3 Freeway.

(4) POL Lines to be Protected by Rectifier #13:

The POL lines from Adit #6 to Aloha Stadium were to be protected by this rectifier. The results of "As Found" pipe-to-soil potentials indicates that these lines are not at a protective potential level.

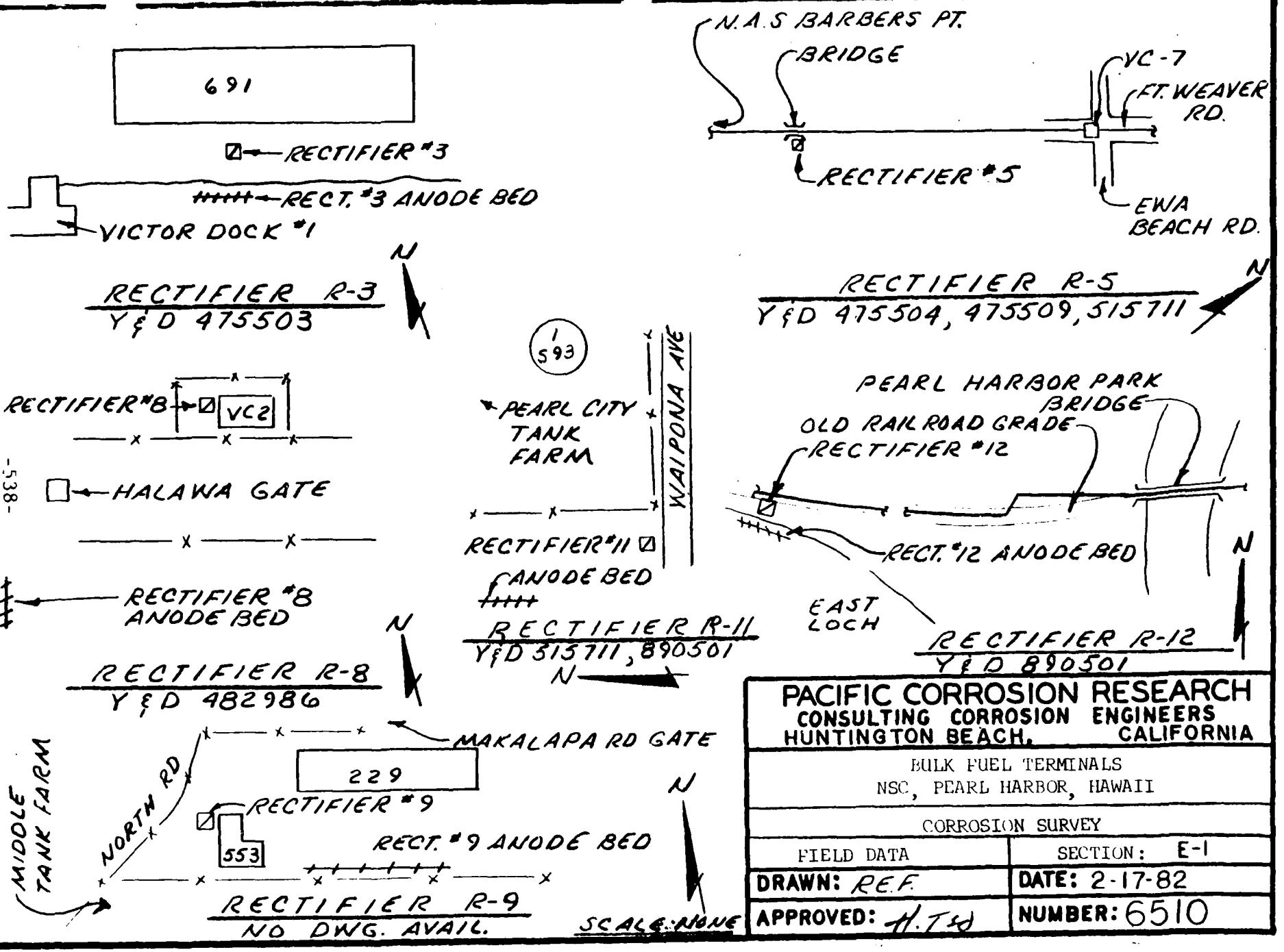
(5) Recommendations:

During this survey, a wire failure in the A.C. power supply to Rectifier #13 was found west of Adit #3 between the first and second pull box. It was repaired immediately and the rectifier placed back in operation. This anode bed should be replaced with ten 4"x80" graphite anodes, a new oil cooled rectifier and an anode watering system, as recommended in Section A-1.

3. Summary.

It is our professional opinion that air cooled rectifiers are generally used for underground structures and/or pipeline applications in areas of dry atmospheres and free of dust. The primary use of oil cooled rectifiers is in the areas i.e. islands, or other marine or industrial environments, where the atmosphere is very corrosive. Oil cooled rectifiers will provice a much longer service life. For locations subject to explosion hazards, such as in Fuel Tank Farms, Fuel Loading Facilities and valve pits, an oil cooled rectifier with explosion proof fittings and housing should be used. It is recommended that oil cooled rectifiers be used in all future designs for this facility.

NOTE: The approximate locations of Existing Rectifiers #3, #5, #8, #9, #11, #12 & #13 are shown on PCR Drawings No. 6510 and 6511.



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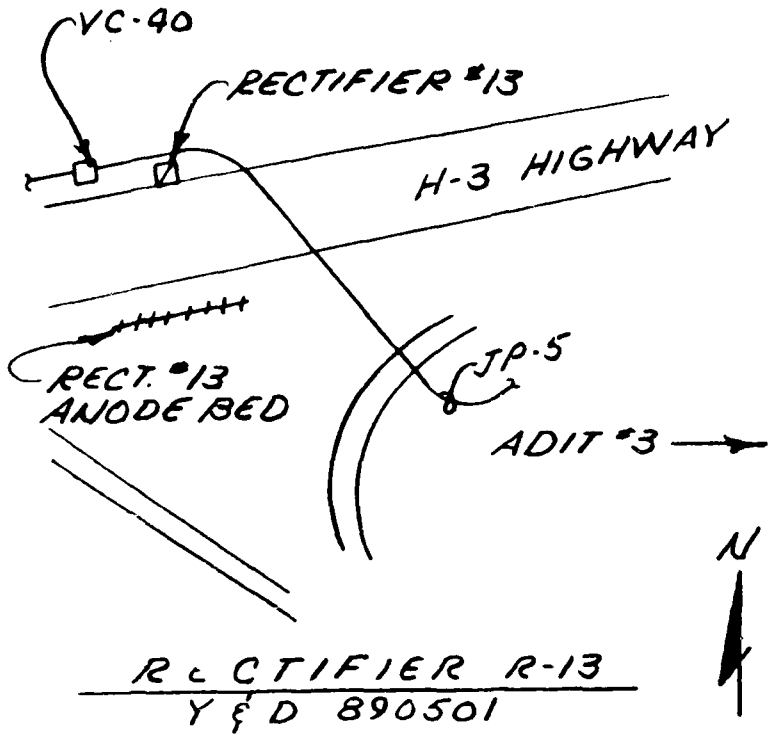
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
HUNTINGTON BEACH, CALIFORNIA

BULK FUEL TERMINALS
NSC, PEARL HARBOR, HAWAII

CORROSION SURVEY

FIELD DATA	SECTION: E-1
DRAWN: R.E.F.	DATE: 2-17-82
APPROVED: H.T.S.	NUMBER: 6510



RECTIFIER R-13
Y&D 890501

SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: E-1
DRAWN: R.E.F.	DATE: 2-17-82
APPROVED: A.J.T.	NUMBER: 6511

SECTION E-2

EXISTING SACRIFICIAL ANODE TYPE OF CATHODIC PROTECTION SYSTEM

SECTION E-2

SUMMARY

Summary

The deletion of insulators on the protected POL lines as called for on the plans has destroyed the effectiveness of the cathodic protection system. When the electrical isolation of a system is in-effective, the system is not at a protective potential level due to shorting to large areas of non-protected metallic structures. The anodes in a sacrificial anode type system will operate at high current values which rapidly reduce the service life of the anodes.

Changes to designed plans and specifications without someone versed in cathodic protection reviewing the changes, could result in the waste of all money expended in anode installation.

SECTION E-2

EXISTING SACRIFICIAL ANODE TYPE OF CATHODIC PROTECTION SYSTEM

1. Description.

A study of the cathodic protection drawings indicates that a total of twenty-eight sacrificial anode beds have been installed in the past. The anode open circuit potentials and the anode bed current output measurements were obtained at each test box. The results of these measurements are shown in Table No. XXII. The locations of these test boxes are shown in PCR Drawings No. 6510 thru 6512.

2. Sacrificial Anode Beds.

A. The following anode beds were installed in 1978 under "Oil Spill Prevention Facilities CP-062", Construction Contract No. N62471-77-C-1346, NAVFAC DWG. No. 7022509:

(1) Test Box #1 - This test box is located 102' north of VC-1. Eight 32 lb. prepackaged magnesium anodes, two anode header cables and five test leads were installed in 1978. Four test leads were found to be broken and/or disconnected from the pipes in this test box. The failed leads were damaged by construction work done in order to install two ballast lines in this area.

(2) Test Box #2 - This test box is located 200' south of VC-2. Fifteen 32 lb. prepackaged magnesium anodes were installed in 1978.

(3) Test Box #3 - This test box is located 185' east of VC-3. Seven 4"x4"x36", 160 lb. zinc anodes were installed in 1978.

(4) Test Box #4 - This test box is located southwest of

VC-5. Four 32 lb. prepackaged magnesium anodes were installed in 1978.

(5) Test Box #6 - This test box is located east of VC-6. Five 4"x4"x36", 150 lb. zinc anodes were installed in 1978.

(6) Test Box #10 - This test box is located 88' east of VC-32. Two 4"x4"x36", 150 lb. zinc anodes were installed in 1978.

We were advised by Mr. Bud Matuse, Inspector, ROICC, on August 27, 1981, that the following construction changes were made under this contract:

a. Deleted all insulators.

b. Deleted test boxes at VC No's. 2, 4, 14 and 19.

c. Deleted test box at Station 54 +88 and installed eight 32 lb. prepackaged magnesium anodes to the anode bed at Test Box #2.

d. Installed seven 150 lb. prepackaged zinc anodes at Test Box #3.

The deletion of insulators on the protected POL lines as called for on the plans has destroyed the effectiveness of the cathodic protection system. When the electrical isolation of a system is in-effective, the system is not at a protective potential level due to shorting to large areas of non protected metallic structures. The anodes in a sacrificial anode type system will operate at high current values which rapidly reduce the service life of the anodes. It is recommended that the installation of

insulators be reconsidered for installation in the near future. It is also recommended that damaged test leads at Test Box #1 be repaired by the construction contractor.

Changes to designed plans and specifications without someone versed in cathodic protection reviewing the changes, wastes all the money expended in anode installations. Please see comments under Conclusions and Recommendations, Section B-1.

B. The following anode beds were installed in 1975, under "Relocation of POL Lines", Construction Contract No. N62471-C-0289, NAVFAC Drawing No.'s 7008523, 7008530, 7008531 and 7008555.

(1) Test Box #5 (Station 8 + 80) - This test box is located west of Building 477 on Kilo Dock - 9 with one 17 lb. prepackaged magnesium anode installed in 1975.

(2) Test Box #7 (Station 4 + 80) - This test box is located west of VC-6 with one 17 lb. prepackaged magnesium anode installed in 1975.

(3) Station 2 + 90 - Can not locate.

(4) Test Box #8 (Station 1 + 80) - This test box is located southwest of Building 474 with one 17 lb. prepackaged magnesium anode installed in 1975.

(5) Station 0 + 80 - Can not locate.

(6) Test Box #9 (Station 0 + 28) - This test box is located 25' north of VC-32. One 17 lb. prepackaged magnesium anode was installed in 1975.

(7) Station 3 + 77.50 - Can not locate.

(8) Station 3 + 42 - Can not locate.

(9) Station 2 + 91.5 - Can not locate.

(10) Station 2 + 28.5 - Can not locate.

(11) Station 1 + 66 - Can not locate.

(12) Station 0 + 93 - Can not locate.

(13) Station 0 + 36.75 - Can not locate.

(14) Test Box #11 (Station 0 + 18.50) - This test box is located 22' west of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975. The test box and the anode was found to be torn out by construction work done in this area in order to install a new steam and air line.

(15) Test Box #12 (Station 0 + 06) - This test box is located 22' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

(16) Test Box #13 (Station 0 + 70) - This test box is located 56' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

(17) Test Box #14 (Station 1 + 40) - This test box is located 116' south of VC-20. One 17 lb. prepackaged magnesium anode was installed in 1975.

No insulators were found to be installed on the protected POL lines during this survey. The isolation of a piping system is very important in a sacrificial anode type cathodic protection system, as we mentioned previously. It is recommended that the missing test boxes be located and brought up to grade. It is also recommended that the con-

struction contractor be requested to install a new test box and a 17 lb. prepackaged magnesium anode at the existing Test Box #11 location.

C. Two anode beds were installed in 1975 under "Replace Lube Oil Lines, Building 88", Construction Contract N62471-73-C-0694. A study of Construction Drawings (Construction Contract N62471-73-C-0694) revealed that the existing two 6" L.O. lines, two 4" L.O. lines and one 4" air line from Building 88 to Mike Docks were replaced with four 6" L.O. lines and one 2½" air line wiht X-Tru-Coated steel in 1975. A sacrificial anode system consisting of two test boxes and four 17 lb. prepackaged magnesium anodes was designed and installed to provide protection for the replaced underground lines. No test boxes were found during this survey.

D. Two Anode Beds on Section B-10 POL Lines:

No cathodic protection system drawings were available at the time of this survey. The cast iron NSFO lines of Section B-10 were found to be protected by a sacrificial anode system. We were advised by Mr. John Kimi that there were test boxes with an unknown number of anodes installed along the POL lines. A majority of these test boxes were covered by asphalt. Only two test boxes were found.

(1) Test Box #15 - This test box with an unknown number of anodes is located southwest of Pumphouse 76.

(2) Test Box #16 - This test box with an unknown number of anodes is located south of Building 371 at Power Plant #3.

During this survey, the cast iron POL lines in Section B-10 were found not electrically continuous from section to section in the line. The sacrificial anode beds, as designed and installed, do not and could not provide protective current for each section of the cast iron lines. To protect a cast iron pipe, first it is necessary to bond across each section of the cast iron line with a suitable size cable. Second, it is necessary to install a system that is capable of providing a large amount of protective current because the current demand for a cast iron line protection is almost double the current demand for the same size bare steel pipe. The bare cast iron pipe requires more protective current because its surface area is approximately twice as much as a similar size bare steel pipe, due to the irregular surface of cast iron pipe.

E. One Anode Bed in Section A-3:

No cathodic protection system drawings were available at the time of this survey. One anode bed was found to be installed in Section A-3 on the north side of Victor Dock #4.

(1) Test Box #17 - Test Station #1 is located on the west side of VC-H with an unknown type and number of anodes.

NOTE: The approximate locations of the existing test boxes are shown on PCR Drawing No. 6512.

SECTION E-2

SACRIFICIAL ANODE BEDS

TABLE NO. XXII

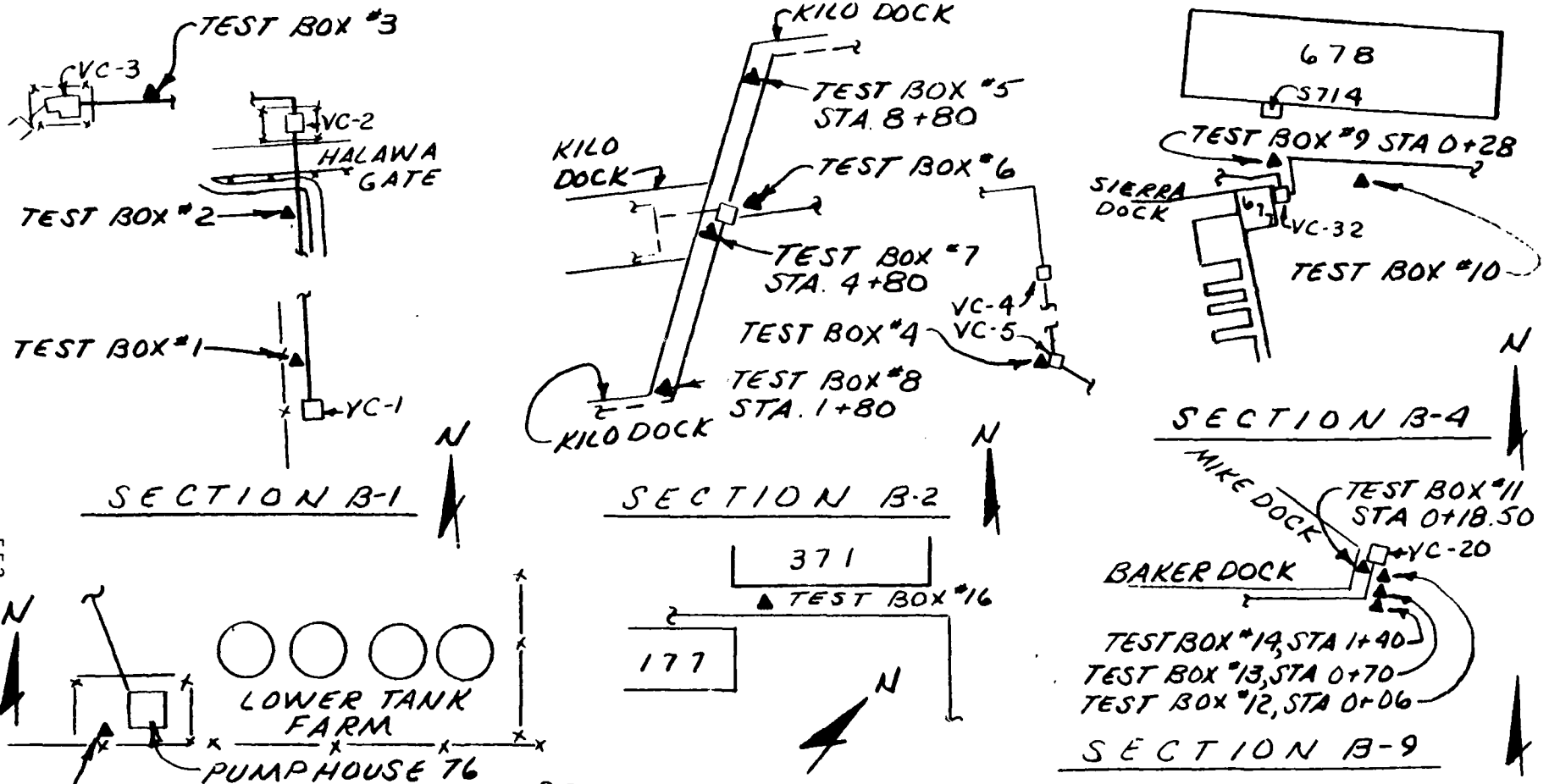
TEST BOX NO & DWG. NO. NAVY DESIG-NATED	PCR	LOCATION	ANODE BED CIRCUIT POTENT. (mv)	ANODE BED CURRENT OUTPUT (ma)	P/S POT. (mv)	SEC. OF LINES TO BE PROTECTED
None	1	N. of VC-1				B-1
NAVFAC DWG. No. 7022509		Anode Lead #1	-1640			
		Anode Lead #2	-1600			
		Test Lead #1		1080	-720	
		Test Lead #2			0 (Broken Lead)	
		Test Lead #3			0 (Broken Lead)	
		Test Lead #4			0 (Broken Lead)	
		Test Lead #5			0 (Broken Lead)	
None	2	200' S of VC-2				B-1
NAVFAC DWG. No. 7022509		Anode Lead	-1660			
		Test Lead #1		15	-1680	
		Test Lead #2			-1680	
None	3	180' E of VC-3				B-1
NAVFAC DWG. No. 7022509		Anode Lead	-1100			
		Test Lead #1		140	-1060	
		Test Lead #2			-1060	
None	4	SW of VC-5				B-2
NAVFAC DWG. No. 7022509		Anode Lead	-1700			
		Test Lead		255	-700	

TEST BOX. NO. & DWG. NO		LOCATION	ANODE BED CIRCUIT POTENT. (mv)	ANODE BED CURRENT OUTPUT (ma)	P/S POT. (mv)	SEC. OF LINES TO BE PROTECTED
NAVY DESIG-NATED	PCR					
8+80	5	W of Bldg. 477				B-2
NAVFAC DWG. No. 7008555		Anode Lead	-1600			
		Test Lead		21	-870	
7+00		W of Bldg. 476	CAN NOT LOCATE (COVERED BY ASPHALT)			
NAVFAC DWG. No. 7008555						
None	6	E of VC-6				B-2
NAVFAC DWG. No. 7022509		Anode Lead	-1100			
		Test Lead #1		440	-780	
		Test Lead #2			-780	
		Test Lead #3			-780	
4+80	7	W of VC-6				B-2
NAVFAC DWG. No. 7008555		Anode Lead	-1450			
		Test Lead		23	-970	
2+90			CAN NOT LOCATE (COVERED BY ASPHALT)			B-2
NAVFAC DWG. No. 7008555						
1+80	8	SW of Bldg. 474				B-2
NAVFAC DWG. No. 7008555		Anode Lead	-1520	23		
		Test Lead			-860	

TEST BOX NO. & DWG. NO.		LOCATION	ANODE BED CIRCUIT POTENT. (mv)	ANODE BED CURRENT OUTPUT (ma)	P/S POT. (mv)	SEC. OF LINES TO BE PROTECTED
NAVY DESIG-NATED	PCR					
0+80 NAVFAC DWG. No. 7008531		CAN NOT LOCATE				B-4
0+28 NAVFAC DWG. No. 7008531	9	E of Bldg. 1588 Anode Lead Test Lead	-1610	168	-850	B-4
3+77.50 NAVFAC DWG. No. 7008531		CAN NOT LOCATE				B-4
3+42 NAVFAC DWG. No. 7008531		CAN NOT LOCATE				B-4
2+91.5 NAVFAC DWG. No. 7008530		CAN NOT LOCATE				B-4
2+28.5 NAVFAC DWG. No. 7008530		CAN NOT LOCATE				B-4
1+66 NAVFAC DWG. No. 7008530		CAN NOT LOCATE				B-4

TEST BOX NO. & DWG. NO.		LOCATION	ANODE BED CIRCUIT POTENT. (mv)	ANODE BED CURRENT OUTPUT (ma)	P/S POT. (mv)	SEC. OF LINES TO BE PROTECTED
NAVY DESIG-NATED	PCR					
0+93 NAVFAC DWG. No. 7008530		CAN NOT LOCATE				B-4
0+36.75 NAVFAC DWG. No. 7008530		CAN NOT LOCATE				B-4
None	10	E of VC-32				B-4
NAVFAC DWG. No. 7022509		Anode Lead #1	-1080			
		Anode Lead #2	-1080			
		Test Lead #1		480	-790	
		Test Lead #2			-790	
0+18.5	11	W of VC-20	Test Box, Test Leads and 17 lb. mag. anode were torn out by construction contractor in December, 1981.			B-9
NAVFAC DWG. No. 7008523 & 7012508						
0+06	12	S of VC-20				B-9
NAVFAC DWG. No. 7008523 & 7012508		Anode Lead	-1580			
		Test Lead		124	-690	
0+70	13	S of T.B #12				B-9
NAVFAC DWG. No. 7008523 & 7012508		Anode Lead	-1540			
		Test Lead		88	-570	

TEST BOX NO. & DWG. NO.		LOCATION	ANODE BED CIRCUIT POTENT. (mv)	ANODE BED CURRENT OUTPUT (ma)	P/S POT. (mv)	SEC. OF LINES TO BE PROTECTED
NAVY DESIG-NATED	PCR					
1+40	14	S of T.B. #13				B-9
NAVFAC DWG. No. 7008523 & 7012508		Anode Lead	-1520			
		Test Lead		110	-630	
None	None	N of Bldg. 88	CAN NOT LOCATE			B-8
		E of POL Lines				
None	None	N of Bldg 88	CAN NOT LOCATE			B-8
		W of POL Lines				
None	15	SW of Pumphouse 76				B-10
No Drawing Available		Anode Lead	-1800			
		Test Lead		18	-510	
None	16	E of Bldg. 371				B-10
No Drawings Available		Anode Lead	-1300			
		Test Lead		23	-1580	
None	17	W of VC-H				A-3
		Anode Lead	-1480			
		Test Lead		48	-1070	



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SCALE: NONE

PACIFIC CORROSION RESEARCH CONSULTING CORROSION ENGINEERS HUNTINGTON BEACH, CALIFORNIA	
BULK FUEL TERMINALS NSC, PEARL HARBOR, HAWAII	
CORROSION SURVEY	
FIELD DATA	SECTION: E-2
DRAWN: R.E.F	DATE: 2-18-82
APPROVED: H. Tso	NUMBER: 6512

SECTION F

CODE OF FEDERAL REGULATIONS, TITLE 49, PART 195

STATUS OF COMPLIANCE AND RECOMMENDATIONS FOR COMPLIANCE

SECTION F

CODE OF FEDERAL REGULATIONS, TITLE 49, PART 195

STATUS OF COMPLIANCE AND RECOMMENDATIONS FOR COMPLIANCE

The Code of Federal Regulations (CFR) is a codification of the general and permanent rules published in the Federal Register by the Executive Departments and Agencies of the Federal Government.

The following recommendations have been prepared upon our professional corrosion knowledge and experience as a general guide for the transportation of fuel and other petroleum products by pipeline. It is intended for use as an aid in understanding and complying with the minimum Federal Safety Standards.

1. Inspection of above ground pipelines, valves and other facilities at six month intervals.
2. All valves must be inspected and partially operated to ensure proper operation, at six month intervals. Partially operate valves to better predict that closure can be obtained when necessary.
3. Lock the valve or provide other means designed to prevent opening of the valve by persons not authorized by the Fuel Department.
4. All valve chambers and rectifiers should be secured with locks. The locks should be checked frequently to ensure that locks can be opened freely at all times.
5. The pressure of the pipelines should be emphasized to ensure the strength of the pipeline. It is the basis to starting point for assuring the strength of a system

used as follows:

a. New Systems - Sets the maximum pressure the pipeline can be operated contingent upon design limitations of the lower pressure components.

b. Operating Systems - Confirms or establishes a need to revise the actual operating pressure.

c. Maintaining Systems - Determines the method of repair in certain pipeline systems and to determine allowable operating pressure in systems where wall thickness has been reduced by corrosion.

6. Material for components of the fuel systems should be chosen for the temperature environment in which components will be used so that the pipeline will maintain its structural integrity.

7. Determine locations of all valves in mains. (Suggest plot on system map and detailed sketches with dimensions to other permanent structures.)

8. The Fuel Department should establish and conduct a continuing training program to instruct operating and maintenance personnel to:

   a. Carry out the operating and maintenance and emergency procedures that relate to their assignments.

   b. Know the characteristics and hazards of the commodities transported.

c. Recognize conditions that are likely to cause emergencies, predict the consequences of facility malfunctions and commodity spills and to take appropriate corrective action.

d. To take steps necessary to control any accidental release of commodity and to minimize the potential for fire, explosion or environmental damage.

e. Learn the proper use of firefighting procedures and equipment, fire suits and breating apparatus.

9. Fuel Department personnel should, in repairing and/or replacing pipelines, insure that the work done is made in a safe manner and is made so as to prevent damage to persons or property.

10. Where a pipeline is to be abandoned in place, the pipeline should be physically disconnected from the supply and seal both ends with a suitable compact material, purge the pipeline if fuel volume is significant enough to become hazardous.

11. Hazardous leaks and potentially hazardous leaks should be repaired promptly. If a pipeline is becoming unsafe due to deterioration and leakage, it should be replaced, repaired or removed from the service.

12. If any repairs are made on the existing POL lines in the future, the exposed areas of the pipe and fittings should be covered with a heavy coat of coal tar enamel.

13. In case of replacement of the existing POL lines in the future, a X-Tru-Coated steel pipe should be used.

14. Each POL line outside of Pearl Harbor Complex should maintain signs (or line markers) visable to the public. Signs should be located directly over the buried line at each road crossing and in sufficient numbers along the remainder of the buried line so that its location is accurately known. The signs should contain the name of the carrier (type of fuel transported) and a telephone number where the carrier can be reached at all times.

As advised by base personnel during this survey, there have been no accidents or injuries in the past at the Bulk Fuel Terminals at the Naval Supply Center, Pearl Harbor, Hawaii. However, in the event of any future leaks, injuries, accidents, repairs and/or replacements of fuel lines, the base personnel should perform certain procedures, and make reports in strict accordance with the Code of Federal Regulations, Title 49, Department of Transportation, Part 195.

The condensed version of CFR-195 has been made a part of this report. This condensed version is used for general information only. It is not to be construed that the portions of CFR-195 not included in this condensed version are not important and should be ignored. At least one updated and complete version of the Code of Federal Regulations, Title 49, Department of Transportation, Part 195 should be maintained at the Base Fuel Department and by the base fuel maintenance personnel. Copies may be obtained from:

SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE
WASHINGTON, D.C. 20402

CFR TITLE 49 PART 195

Transportation of Liquids by Pipeline.

Subpart A - General

1. 195.1 Scope.

This part prescribes rules governing the transportation by pipeline in interstate and foreign commerce of hazardous materials that are subject to Part 172 (commodity list of hazardous materials containing the shipping name), Part 173 (shippers), petroleum, and petroleum products.

2. 195.4 Acceptable petroleum commodities.

No carrier may transport any petroleum or petroleum product unless the petroleum or petroleum product is chemically compatible with both the pipeline, including all components, and any other commodity that it may come into contact with while in the pipeline.

3. 195.6 Transportation of Certain Commodites.

(a) Except for petroleum, petroleum products, natural gasoline, and liquefied petroleum gases, no carrier may transport any commodity unless the carrier notifies the Secretary in writing, with the information listed in paragraph (b) of this section, at least 90 days before the date the transportation is to begin. If the Secretary determines that the transportation of the commodity in the manner proposed would be unduly hazardous, he will, within 90 days after receipt of the notice, order the carrier, in writing not to transport the commodity in the proposed manner until further notice. As soon as practicable after issuance of such an order, the Secretary will initiate appropriate action to deter-

mine whether and in what manner the commodity may be transported without undue hazard.

(b) The notice submitted to the Administrator by the carrier must state the chemical name, common name, hazard classification determined in accordance with Part 173 of this chapter, properties, and characteristics of the commodity to be transported. It must also include design specifications, including materials used in construction of the pipeline and the maximum operating pressures for the pipeline through which the commodity is to be transported.

4. 195.8 Transportation of Commodities in Pipelines Constructed with other than Steel Pipe.

No carrier may transport any commodity through a pipe that is constructed after October 1, 1970, of material other than steel unless the carrier has notified the Secretary in writing at least 90 days before the transportation is to begin. The notice must state the chemical name, common name, hazard classification (if any) determined in accordance with Part 173 of this chapter, properties, and characteristics of the commodity to be transported and the material used in construction of the pipeline. If the Secretary determines that the transportation of the commodity in the manner proposed would be unduly hazardous, he will, within 90 days after receipt of the notice order the carrier, in writing not to transport the commodity in the proposed manner until further notice.

Subpart B - Accident Reporting.

1. 195.50 Scope.

This subpart prescribes rules governing the reporting

of any failure in a pipeline system subject to this part in which there is a release of the commodity transported resulting in any of the following:

(a) Explosion or fire not intentionally set by the carrier.

(b) Loss of 50 or more barrels of liquid.

(c) Escape to the atmosphere of more than five barrels a day of highly volatile liquids.

(d) Death of any person.

(e) Bodily harm to any person resulting in one or more of the following:

(1) Loss of consciousness.

(2) Necessity to carry the person from the scene.

(3) Necissity for medical treatment.

(4) Disability which prevents the discharge of normal duties or the pursuit of normal activities beyond the day of the accident.

(f) Property damage of at least $1,000 to other than the carrier's facilities, based upon actual cost or reliable estimates.

2. 195.52 Telephonic notice of certain accidents.

(a) At the earliest practicable moment following discovery of a release of the commodity transported resulting in an event described in 195.50, each carrier shall give notice, in accordance with paragraph (b) of this section, of any failure that -

(1) Caused a death or a personal injury requiring hospitalization;

(2) Resulted in either a fire or explosion not

intentionally set by the carrier:

(3) Caused estimated damage to the property of the carrier or others, or both, of a total of $5,000 or more:

(4) Resulted in pollution of any stream, river, lake, reservoir, or other similar body of water that violated applicable water quality standards, caused a discoloration of the surface of the water or adjoining shoreline, or deposited a sludge or emulsion beneath the surface of the water or upon adjoining shorelines; or

(5) In the judgment of the carrier, was significant even though it did not meet the criteria of any other paragraph of this section.

(b) Reports made under paragraph (a) of this section are made by telephone to area code 202, 426-0700 and must include the following information:

(1) Name and address of the carrier.

(2) Name and telephone number of the reporter.

(3) The location of the failure.

(4) The time of the failure.

(5) The fatalities and personal injuries, if any.

(6) All other significant facts known by the carrier that are relevant to the cause of the failure or extent of the damages.

3. 195.54 Accident reporting.

Each carrier that experiences an accident that is required to be reported under this subpart shall, as soon as practicable but not lather than 15 days after discovery of the acci-

dent, prepare and file an accident report, on DOT Form 7000-1 or a facsimile, with the Director, Office of Pipeline Safety, Department of Transportation, Washington, D.C. 20590. The carrier shall file two copies of each report and shall retain one copy at its principal place of business.

4. 195.56 Instructions for preparing DOT Form 7000-1.

(a) Each carrier shall prepare each report of an accident on DOT Form 7000-1 or a facsimile, in accordance with the following instructions:

(1) General. Each applicable item must be marked or filled in as fully and as accurately as information accessible to the carrier at the time of filing the report will be made.

(2) Part A. Enter name as it is filed with the Interstate Commerce Commission. If the carrier's name is not filed with the Commission, enter the complete corporate name of the carrier. Enter the address of the carrier's principal place of business including zip code.

(3) Part B, Item 1. Enter the date the accident occurred or was discovered. If the accident was not discovered on the date it occurred, state this fact on the back of the form.

(4) Part B, Item 2. Enter the exact time in hours and minutes (i.e., 10:15) if known or a time range (i.e., 10:11) if exact time is not known. If the accident was not discovered on the date it occurred, enter the time it was discovered and state this fact, on the back of the form as in Part B, Item 1.

(5) Part B, Item 3. Enter all three names, State, county, city, or town, in or near which accident occurred.

(6) Part B, Item 4. Mark the appropriate box. If "other" is marked, state clearly on form what part of the pipeline system.

(7) Part B, Item 5. If the accident occurred in an uninhabited area, such as woods, cultivated field, swamp, etc., so state clearly on the form under Item 5. If not, attach a sketch to the form showing the part of the pipeline system where the accident occurred, and the location of the accident as related to significant landmarks. Each item shown on the sketch must be clearly and distinctly marked to identify it. Approximate distances from accident location to all landmarks shown on the sketch must be indicated.

(8) Part C. Mark the appropriate box or boxes. If applicable, mark more than one box. If "other" is marked, state clearly on form the exact origin of the release of commodity.

(9) Part D. Mark the appropriate box. If "other" is marked, clearly state the cause of the accident.

(10) Part E. Indicate a number under each heading including "0" if none. Report deaths, even if previously reported in accordance with 195.52.

(11) Part F, Items 1 and 2. Report anly material in the pipeline system that was actually damaged such as pipe, valves, or fittings. Do not include cost of commodity which was lost due to the accident or fittings used during repair which became permanently attached to the system. The dollar value of damage should be based on replacement at present day costs.

(12) Part F, Items 3 and 4. This is damage to

property other than that of the carrier. Dollar value must be actual or the best estimate available.

(13) Part G, Item 1. State the commonly used name of the commodity such as fuel oil, regular gasoline, liquefied petroleum gas. If the commodity name is one not commonly used, state the name here and give a brief description of it under "Account of Accident by Responsible Official of Carrier."

(14) Part G, Item 3. State the year facility was installed or the best estimate possible. Pipe is excluded as the year of installation is required in Item 4 of Part H.

(15) Part H. Mark appropriate boxes and state information required in all items of this part if the accident occurred in line pipe. If the accident occurred in any other part of the pipeline system, omit this part.

(16) Part I. Mark appropriate boxes and state information required in all items of this part if the accident was caused by corrosion in any component of the pipeline system. In Item 4, state the length of time between the type of tests, such as pipe-to-soil potential, stated in Item 5.

(17) Part J. Complete all three items only if the accident was caused by equipment rupturing the pipeline. In Item 2, all the information stated on the closest line marker must be shown.

(b) In addition to the requirements of paragraph (a) of this section, in the space provided after Part J, the carrier shall enter an account of the accident containing the most reliable information to which the carrier has access at the time

of reporting, sufficiently detailed and complete to convey an understanding of the accident. This account may be continued on an extra sheet of paper if more space is needed.

(c) At the bottom of the back of DOT Form 7000-1 the carrier shall state the name and title of the pipeline official responsible for compiling and filing the report along with the telephone numer at which this official can be reached, and the date the report was completed.

5. 195.58 Changes in or additions to accident report.

Whenever a carrier receives any changes in the information reported or additions to the original report on DOT Form 7000-1 it shall immediately file a supplemental report with the Director, Office of Pipeline Safety, Department of Transportation, Washington, D.C. 20590.

6. 195.60 Carrier assistance in investigation.

If the Department of Transportation investigates an accident, the carrier involved shall make available to the representative of the Department all records and information that in any way pertain to the accident, and shall afford all reasonable assistance in the investigation of the accident.

7. 195.62 Supplies of accident report DOT Form 7000-1.

Each carrier shall maintain an adequate supply of forms that are a facsimile of DOT Form 7000-1 to enable it to promptly report accidents. The Department will, upon request, furnish specimen copies of the form. Requests should be addressed to the Director, Office of Pipeline Safety, Department of Transportation, Washington, D.C. 20590.

Subpart C - Design requirements for the design requirements of new pipeline, referred to "code of Federal Regulations" Title 49. Part 195. Subpart C, page 573 thru 576. However the following regulations should be considered by Naval Personnel.

1. 195.112 New Pipe.

Any new pipe installed in a pipeline system must comply with the following:

(a) The pipe must be made of steel of the carbon, low alloy-high strength, or alloy type that is able to withstand the internal pressures and external loads and pressures anticipated for the pipeline system.

(b) The pipe must be made in accordance with a written pipe specification that sets forth the chemical requirements for the pipe steel and mechanical tests for the pipe to provide pipe suitable for the use intended.

(c) Each length of pipe with an outside diameter of 4 inches or more must be marked on the pipe or pipe coating with the specification to which it was made, the specified minimum yield strength or grade, and the pipe size. The marking must be applied in a manner that does not damage the pipe for pipe coating and must remain visible until the pipe is installed.

2. 195.111 Used pipe.

Any used pipe installed in a pipeline system must comply with 195.112. (a) and (b) and the following:

(a) The pipe must be of a known specification and the seam joint factor must be determined in accordance with 195.106 (d). If the specified minimum yield strength or the wall thick-

ness is not known, it is determined in accordance with 195.106 (b) or (c) as appropriate.

(b) There may not be any -

(1) Buckles;

(2) Cracks, grooves gouges, dents, or other surface defects that exceed the maximum depth of such a defect permitted by the specification to which the pipe was manufactured; or

(3) Corroded areas where the remaining wall thickness is less than the minimum thickness required by the tolerances in the specification to which the pipe was manufactured.

However, pipe that does not meet the requirements of paragraph (a) (3) of this section may be used if the operating pressure is reduced to be commensurate with the remaining wall thickness.

3. 195.116 Valves.

Each valve installed in a pipeline system must comply with the following:

(a) The valve must be of a sound engineering design.

(b) Materials subject to the internal pressure of the pipeline system, including welded and flanged ends, must be compatible with the pipe or fittings to which the valve is attached.

(c) The commodity stream must be made of materials that are compatible with each commodity that it is anticipated will flow through the pipeline system.

(d) Each valve must be both hydrostatically shell tested and hydrostatically seat tested without leakage to at least the requirements set forth in section 5 of API Standard 6D.

(e) Each valve other than a check valve must be equipped with a means for clearly indicating the position of the valve (open, closed, etc.).

(f) Each valve must be marked on the body or the nameplate, with at least the following:

(1) Manufacturer's name or trademark.

(2) Class designation or the maximum working pressure to which the valve may be subjected.

(3) Body material designation (the end connection material, if more than one type is used).

(4) Nominal valve size.

4. 195.118 Fittings.

(a) Butt-welding type fittings must meet the marking end preparation and the bursting strength requirements of ANSI B 16.9 or MSS Standard Practice SP-75, except that fittings manufactured, designed, or installed before July 1, 1976, may meet the requirements of MSS Standard Practice SP-48 or MSS Standard Practice SP-63.

(b) There may not be any buckles, dents, cracks, gouges, or other defects in the fitting that might reduce the strength of the fitting.

(c) The fitting must be suitable for the intended service and be at least as strong as the pipe and other fittings in the pipeline system to which it is attached.

5. 195.126 Flange connection.

Each component of a flange connection must be compatible with each other component and the connection as a unit must be

suitable for the service in which it is to be used.

6. 195.128 Station piping.

Any pipe to be installed in a station that is subject to system pressure must meet the applicable requirements of this subpart.

Subpart D - Construction.

1. 195.200 Scope.

This subpart prescribes minimum requirements for constructing new pipeline systems with steel pipe, and for relocating replacing, or otherwise changing existing pipeline systems that are constructed with steel pipe. However, this subpart does not apply to the movement of pipe covered by 195.424.

2. 195.202 Compliance with specifications or standards.

Each pipeline system must be constructed in accordance with comprehensive written specifications or standards that are consistent with the requirements of this part.

3. 195.204 Inspection-general.

Inspection must be provided to ensure the installation of pipe or pipeline systems in accordance with the requirements of this subpart. No person may be used to perform inspections unless that person has been trained and is qualified in the phase of construction he is to inspect.

4. 195.206 Material inspection.

No pipe or other component may be installed in a pipeline system unless it has been visually inspected at the site of installation to ensure that it is not damaged in a manner that could impair its strength or reduce its serviceability.

5. 195.208 Welding of supports and braces.

Supports or braces may not be welded directly to pipe that will be operated at a pressure of more than 100 p.s.i.g.

6. 195.210 Pipeline location.

(a) Pipeline right-of-way must be selected to avoid, as far as practicable, areas containing private dwellings, industrial buildings, and places of public assembly.

(b) No pipeline may be located within 50 feet of any private dwelling, or any industrial building or place of public assembly in which persons work, congregate, or assemble, unless it is provided with at least 12 inches of cover in addition to that prescribed in 195.248.

7. 195.212 Bending of pipe.

(a) Pipe must not have a wrinkle bend.

(b) Each field bend must comply with the following:

(1) A bend must not impair the serviceability of the pipe.

(2) Each bend must have a smooth contour and be free from buckling, cracks, or any other mechanical damage.

(3) On pipe containing a longitudinal weld, the longitudinal weld must be as near as practicable to the neutral axis of the bend unless -

(i) The bend is made with an internal bending mandrel; or

(ii) The pipe is 12 inches or less in outside diameter or has a diameter to wall thickness ration less than 70.

(c) Each circumferential weld which is located where the stress during bending causes a permanent deformation in the

pipe must be nondestructively tested either before or after the bending process.

8. 195.214 Welding: General.

(a) Welding must be performed in compliance with this section and compliance with this section and 195.218 through 195.234.

(b) Welding must be performed in accordance with established written welding procedures that have been tested to assure that they will produce sound, ductile welds that comply with requirements of this subject. Detailed records of these tests must be kept by the carrier involved.

9. 195.216 Welding: miter joints.

A miter joint is not permitted (not including deflections up to 3 degrees that are caused by misalignment).

10. 195.218 Welding: Seam offset.

Seams on adjacent pipe lengths must be offset.

11. 195.220 Welds: Filler metal.

Filler metal must be at least equal in strength to the highest specified minimum yield strength of the pieces being welded and must fuse the pieces together.

12. 195.222 Welders: Testing.

Each welder must be qualified in accordance with one of the following editions of Section 3 of API Standard 1104:

(a) The 1973 edition, except that a welder may be qualified by radiography under subsection 3.51 without regard for the standards in subsection 6.9 for depth of undercutting adjacent to the root bead unelss that depth is visually determined by use of a depth measuring device on all undercutting along the entire circumference of the weld; or

(b) If a welder is qualified before March 20, 1975, the 1968 edition, except that a welder may not requalify under the 1968 edition.

13. 195.224 Welding: Weather.

Welding must be protected from weather conditions that would impair the quality of the completed weld.

14. 195.226 Welding: Arc burns.

(a) Each arc burn must be repaired.

(b) An arc burn may be repaired by completely removing the notch by grinding, if the grinding does not reduce the remaining wall thickness to less than the minimum thickness required by the tolerances in the specification to which the pipe is manufactured. If a notch is not repairable by grinding, a cylinder of the pipe containing the entire notch must be removed.

(c) A ground may not be welded to the pipe or fitting that is being welded.

15. 195.228 Welds and welding inspection: Standards of acceptability.

(a) Each weld and welding must be inspected to insure compliance with the requirements of this subpart. Visual inspection must be supplemented by nondestructive testing.

(b) The acceptability of a weld is determined according to the standards in Section 6 of the 1973 edition of API Standard 1104. However, the standards in subsection 6.9 for depth of undercutting adjacent to the root bead apply only if -

(1) That depth is visually determined by use of a depth measuring device on all undercutting along the entire circumference of the weld; and

(2) Visual determination of internal undercutting is made in all pipe of the same diameter in a pipeline, except where impractical at tie-in welds.

16. 195.230 Welds: Repair of defects.

(a) Except as provided in paragraph (b) of this section, a weld that is found unacceptable under 195.228 may not be repaired unless -

(1) There are no cracks in the weld:

(2) The segment of the weld to be repaired was not previously repaired: and

(3) The weld is inspected after repair to assure its acceptability.

(b) In the case of offshore pipelines, a weld on a pipeline being installed from a pipelay vessel may be repaired if the repair is made in accordance with established written welding procedures that have been tested under 195.214 to assure that they will product sound ductile welds.

17. 195.232 Welds: Removal of defects.

Except for offshore pipelines being installed from a pipelay vessel, a cylinder of the pipe containing the weld must be removed and the ends rebeveled whenever -

(a) The weld contains one or more cracks;

(b) The weld is not acceptable under 195.228 and is not repaired; or

(c) The weld was repaired and the repair did not meet the requirements of 195.228.

18. 195.234 Welds: Nondestructive testing and retention of testing records.

(a) A weld may be nondestructively tested by any process that will clearly indicate any defects that may affect the integrity of the weld.

(b) Any nondestructive testing of welds must be performed -

(1) In accordance with a written set of procedures for nondestructive testing; and

(2) With personnel that have been trained in the established procedures and in the use of the equipment employed in the testing.

(c) Procedures for the proper interpretation of each weld inspection must be established to ensure the acceptability of the weld under 195.228.

(d) During construction, at least 10 percent of the girth welds made by each welder during each welding day must be nondestructively tested over the entire circumference of the weld.

(e) In the following locations, 100 percent of the girth welds must be nondestructively tested:

(1) At any onshore location where a loss of commodity could reasonably be expected to pollute any stream, river, lake, reservoir, or other body of water, and any offshore area unless impracticable, in which case only 90 percent of each day's welds need be tested.

(2) Within railroad or public road rights-of-way.

(3) At overhead road crossings and within tunnels.

(4) At pipeline tie-ins.

(5) Within the limits of any incorporated subdivision of a State government.

(6) Within populated areas, including but not limited to, residential subdivisions, shopping centers, schools, designated commercial areas, industrial facilities, public institutions, and places of public assembly.

(f) When installing used pipe, 100 percent of the old girth welds must be nondestructively tested.

(g) A record of the nondestructive testing must be retained by the carrier who is involved, including (if radiography is used) the developed film with so far as practicable, the location of the weld. This record must be retained for 3 years after the line is placed in operation.

19. 195.236 External corrosion portection.

Each component in the pipeline system must be provided with protection against external corrosion.

20. 195.238 External coating.

(a) No pipeline system component may be buried or submerged unless that component has an external protective coating that -

(1) Is designed to mitigate corrosion of the buried or submerged component;

(2) Has sufficient adhesion to the metal surface to prevent underfilm migration of moisture;

(3) Is sufficiently ductile to resist cracking;

(4) Has enough strength to resist damage due to handling and soil stress; and

(5) Supports any supplemental cathodic protection.

In addition, if an insulating-type coating is used it must have low moisture absorption and provide high electrical re-

sistance.

(b) All pipe coating must be inspected just prior to lowering the pipe into the ditch or submerging the pipe, and any damage discovered must be repaired.

21. 195.242 Cathodic protection system.

(a) A cathodic protection system must be installed for all buried or submerged facilities to mitigate corrosion that might result in structural failure. A test failure. A test procedure must be developed to determine whether adequate cathodic protection has been achieved.

(b) A cathodic protection system must be installed not later than 1 year after completing the construction.

22. 195.244 Test leads.

(a) Except for offshore pipelines, electrical test leads used for corrosion control or electrolysis testing must be installed at intervals frequent enough to obtain electrical measurements indicating the adequacy of the cathodic protection.

(b) Test leads must be installed as follows:

(1) Enough looping or slack must be provided to prevent test leads from being unduly stressed or broken during backfilling.

(2) Each lead must be attached to the pipe so as to prevent stress concentration on the pipe.

(3) Each lead installed in a conduit must be suitably insulated from the conduit.

23. 195.246 Installation of pipe in a ditch.

(a) All pipe installed in a ditch must be installed in a manner that minimizes the introduction of secondary stresses and

the possibility of damage to the pipe.

(b) All offshore pipe in water at least 12 feet deep but not more than 200 feet deep, as measured from the mean low tide, must be installed so that the tope of the pipe is below the natural bottom unless the pipeline is supported by stanchions, held in place by anchors or heavy concrete coating, or an equivalent level of protection is provided.

24. 195.248 Cover over buried pipeline.

(a) Unless specifically exempted in this subpart, all pipe must be buried so that it is below the level of cultivation. Except as provided in paragraph (b) of this section, the pipe must be installed so that the cover between the tope of the pipe and the ground level, road bed, river bottom, or sea bottom, as applicable complies with the following table:

Location	Cover (inches)	
	For normal excavation	For rock excavation
Industrial, commercial, and residential areas.....	36	30
Crossings of inland bodies of water with a width of at least 100 ft. from high water mark to high water mark...	48	18
Drainage ditches at publich roads and railroads.....	36	36
Deepwater port safety zone.....	48	24
Other offshore areas under water less than 12 ft. deep as measured from the mean low tide.....	36	18
Any other area.....	30	18

Rock excavation is any excavation that requires blasting or removal by equivalent means.

(b) Less cover than the minimum required by paragraph (a) of this section and 195.210 may be used if -

(1) It is impracticable to comply with the minimum cover requirements; and

(2) Additional protection is provided that is equivalent to the minimum required cover.

25. 195.250 Clearance between pipe and underground structures.

Any pipe installed underground must have at least 12 inches of clearance between the outside of the pipe and the extremity of any other underground structure, except that for drainage tile the minimum clearance may be less than 12 inches but not less than 2 inches. However, where 12 inches of clearance is impracticable the clearance may be reduced if adequate provisions are made for corrosion control.

26. 195.252 Backfilling.

Backfilling must be performed in a manner that protects any pipe coating and provides firm support for the pipe.

27. 195.254 Above ground components.

(a) Any component may be installed above ground in the following situations, if the other applicable requirements of this part are complied with:

(1) Overhead crossings of highways, railroads, or a body of water.

(2) Spans over ditches and gullies.

(3) Scraper traps or block valves.

(4) Areas under the direct control of the carrier.

(5) In any area inaccessible to the public.

(b) Each component covered by this section must be protected from the forces exerted by the anticipated loads.

28. 195.256 Crossing of railroads and highways.

The pipe at each railroad or highway crossing must be installed so as to adequately withstand the dynamic forces exerted by anticipated traffic loads.

29. 195.258 Valves: General.

(a) Each valve must be installed in a location that is accessible to authorized employees and that is protected from damage or tampering.

(b) Each submerged valve located offshore or in inland navigable waters must be marked, or located by conventional survey techniques, to facilitate quick location when operation of the valve is required.

30. 195.260 Valves: Location.

A valve must be installed at each of the following locations:

(a) On the suction end and the discharge end of a pump station in a manner that permits isolation of the pump station equipment in the event of an emergency.

(b) On each line entering or leaving a tank farm in a manner that permits isolation of the tank farm from other facilities.

(c) On each mainline at locations along the pipeline system that will minimize damage or pollution from accidental liquid discharge, as appropriate for the terrain in open country,

for offshore areas, or for populated areas.

(d) On each lateral takeoff from a trunk line in a manner that permits shutting off the lateral without interrupting the flow in the trunk line.

(e) On each side of a water crossing that is more than 100 feet wide from high-water mark to high-water mark unless the Secretary finds in a particular case that valves are not justified.

(f) On each side of a reservoir holding water for human consumption.

31. 195.262 Pumping equipment.

(a) Adequate ventilation must be provided in pump station buildings to prevent the accumulation of hazardous vapors. Warning devices must be installed to warn of the presence of hazardous vapors in the pumping station building.

(b) The following must be provided in each pump station:

(1) Safety devices that prevent overpressuring of pumping equipment, including the quxiliary pumping equipment within the pumping station.

(2) A device for the emergency shutdown of each pumping station.

(3) If power is necessary to actuate the safety devices, an auxilliary power supply.

(c) Each safety device must be tested under conditions approximating actual operations and found to function properly before the pumping station may be used.

(d) Except for offshore pipelines pumping equipment may not be installed -

(1) On any property that will not be under the control of the carrier; or

(2) Less than 50 feet from the boundary of the station.

(e) Adequate fire protection must be installed at each pump station. If the fire protection system installed requires the use of pumps, motive power must be provided for those pumps that is separate from the power that operates the station.

32. 195.266 Above ground tanks.

(a) A means must be provided for containing liquids in the event of spillage or tank failure.

(b) Tankage areas must be adequately protected against unauthorized entry.

(c) Normal and emergency relief venting must be provided for each tank.

33. 195.266 Construction records.

A complete record that shows the following must be maintained by the carrier involved for the life of each facility:

(a) The total number of girth welds and the number nondestructively tested, including the number rejected and the disposition of each rejected weld.

(b) The amount, location, and cover of each size of pipe installed.

(c) The location of each crossing of another pipeline.

(d) The location of each buried utility crossing.

(e) The location of each overhead crossing.

(f) The location of each valve, weighted pipe, corrosion test station, or other item connected to the pipe.

Subpart E - Hydrostatic Testing.

1. 195.300 Scope.

This subpart prescribes minimum requirements for hydrostatic testing of newly constructed steel pipeline systems and for hydrostatic testing of existing steel pipeline systems that are relocated, replaced, or otherwise changed. However, this subpart does not apply to the movement of pipe covered by 195.424.

2. 195.302 General requirements.

(a) Each new pipeline system, each pipeline system in which pipe has been relocated or replaced, or that part of a pipeline system that has been relocated or replaced, must be hydrostatically tested in accordance with this subpart without leakage.

(b) The test pressure for each hydrostatic test conducted under this section must be maintained for at least 24 hours throughout the part of the system that is being tested.

3. 195.304 Testing of components.

(a) Each hydrostatic test under 195.302 must test all pipe and attached fittings, including components, unless otherwise permitted by paragraph (b) of this section.

(b) A component that is the only item being replaced or added to the pipeline system need not be hydrostatically tested under paragraph (a) of this section if the manufacturer certifies that either -

(1) The component was hydrostatically tested at the factory; or

(2) The component was manufactured under a quality

control system that ensures each component is at least equal in strength to a prototype that was hydrostatically tested at the factory.

4. 195.306 Test medium.

(a) Except as provided in paragraph (b) of this section, water must be used as the test medium.

(b) Except for offshore pipelines, liquid petroleum that does not vaporize rapidly may be used as the test medium if -

(1) The entire pipeline section under test is outside of cities and other populated areas;

(2) Each building within 300 feet of the test section is unoccupied while the test pressure is equal to or greater than a pressure which produces a hoop stress of 50 percent of specified minimum yield strength;

(3) The test section is kept under surveillance by regular patrols during the test; and

(4) Continuous communication is maintained along entire test section.

5. 195.308 Testing of tie-ins.

Pipe associated with tie-ins must be hydrostatically tested, either with the section to be tied in or separately.

6. 195.310 Records.

(a) A record must be made of each hydrostatic test and that record must be retained as long as the facility tested is in use.

(b) The record required by paragraph (a) of this section must include the recording gauge charts, dead weight tester data, and the reasons for any failure during a test. Where

elevation differences in the section under test exceed 100 feet, a profile of the pipeline that shows the elevation and test sites over the entire length of the test section must be included. Each recording gauge chart must also contain -

(1) The carrier's name, the name of the person responsible for making the test, and the name of the test company used, if any;

(2) The date and time of the test;

(3) The minimum test pressure;

(4) The test medium;

(5) A description of the facility tested; and

(6) An explanation of any pressure discontinuities that appear on any chart.

Subpart F - Operation and Maintenance.

1. 195.400 Scope.

This subpart prescribes minimum requirements for operating and maintaining pipeline systems constructed with steel pipe.

2. 195.401 General Requirements.

(a) No carrier may operate or maintain its pipeline systems at a level of safety lower than that required by this subpart and the procedures it is required to establish under 195.402 (a) of this subpart.

(b) Whenever a carrier discovers any condition that could adversely affect the safe operation of its pipeline system, it shall correct it within a reasonable time. However, if the condition is of such a nature that it presents an immediate hazard to persons or property, the carrier may not operate the affected part of the system until it has corrected the unsafe

condition.

(c) No carrier may operate any part of a pipeline system upon which construction was begun after March 31, 1970, or in the case of offshore pipelines located between a production facility and a carrier's trunkline reception point, after July 31, 1977, unless it was designed and constructed as required by this part.

3. 195.402 Procedural manual for operations, maintenance, and emergencies.

(a) General. Each carrier shall prepare and follow for each pipeline system a manual of written procedures for conducting normal operations and maintenance activities and handling abnormal operations and emergencies.

This manual shall be reviewed annually and appropriate changes made as necessary to insure that the manual is effective. This manual shall be prepared before initial operations of a pipeline system commence and appropriate parts shall be kept at locations where operations and maintenance activities are conducted.

(b) Amendments. If the Secretary finds that a carrier's procedures are inadequate to assure safe operation of the system or to minimize hazards in an emergency, the Secretary may, after issuing a notice of amendment and providing an opportunity for an informal hearing, require the carrier to amend the procedures. In determining the adequacy of the procedures, the Secretary considers pipeline safety data, the feasibility of the procedures, and whether the procedures are appropriate for the pipeline system involved. Each notice of amendment shall allow

the carrier at least 15 days after receipt of such notice to submit written comments or request an informal hearing. After considering all material presented, the Secretary shall notify the carrier of the required amendment or withdraw the notice proposing the amendment.

(c) Maintenance and Normal Operations. The manual required by paragraph (a) of this section must include procedures for the following to provide safety during maintenance and normal operations:

(1) Making construction records, maps, and operating history available as necessary for safe operation and maintenance.

(2) Gathering of data needed for reporting accidents under Subpart B of this part in a timely and effective manner.

(3) Operating, maintaining, and repairing the pipeline system in accordance with each of the requirements of this subpart.

(4) Determining on the basis of design, construction, leak history, and other relevant data, which pipeline facilities, operating conditions, installation techniques, and maintenance methods would cause hazards to the safety of the public or system integrity in the event of a malfunction or failure.

(5) Analyzing pipeline accidents to determine their causes (in cooperation with the Secretary when appropriate).

(6) Minimizing the potential for hazards identified under paragraph (c) (4) of this section and the possibility

of recurrence of accidents analyzed under paragraph (c)(5) of this section.

(7) Starting up and shutting down any part of the pipeline system in a manner designed to assure operation within the limits prescribed by 195.406, consider the commodity in transportation, variations in altitude along the pipeline, and pressure monitoring and control devices.

(8) Monitoring from an attended location pipeline pressure during start up until steady state pressure and flow conditions are reached and suring shut-in to assure operation within limits prescribed by 195.406.

(9) Detecting abnormal operating conditions at points of receipt and delivery of the commodity and at facilities identified under paragraph (c)(4) of this section by monitoring pressure, temperature, flow, or other appropriate operational data and transmitting this to an attended location.

(10) Abandoning pipeline facilities, including safe disconnection from an operating pipeline system, purging of combustibles, and sealing abandoned facilities left in place to minimize safety and environmental hazards.

(11) Minimizing the likelihood of accidental ignition of vapors in areas near facilities identified under paragraph (c)(4) of this section where the potential exists for the presence of flammable liquids or gases.

(12) Establishing and maintaining liaison with fire, police, and other appropriate public officials to learn the responsibility and resources of each government organization

that may respond to a liquid pipeline emergency and acquaint the officials with the carrier's ability in responding to a liquid pipeline emergency and means of communication.

(13) Periodically reviewing the work done by carrier personnel to determine the effectiveness of the procedures used in normal operation and maintenance and taking corrective action where deficiencies are found.

(14) Any other items reasonably considered necessary for the safe operation and maintenance of the system.

(d) Abnormal Operation. The manual required by paragraph (a) of this section must include procedures for the following to provide safety when operating design limits have been exceeded:

(1) Responding to, investigating, and correcting the cause of:

(i) Unintended closure of valves or shutdowns;

(ii) Increase or decrease in pressure or flow rate outside normal operating limits;

(iii) Loss of communications;

(iv) Operation of any safety device;

(v) Any other malfunction of a component, deviation from normal operation, or personnel error which could cause a hazard to persons or property.

(2) Checking variations from normal operation after abnormal operation has ended, including pressure and flow rates at outlet and inlet facilities and at sufficient critical locations in the system to determine continued integrity and safe operation.

(3) Correcting variations from normal operation of pressure and flow equipment and controls.

(4) Notifying responsible carrier personnel when notice of an abnormal operation is received.

(5) Periodically reviewing the response of carrier personnel to determine the effectiveness of the procedures controlling abnormal operation and taking corrective action where deficiencies are found.

(e) Emergencies. The manual required by paragraph (a) of this section must include procedures for the following to provide safety when an emergency condition occurs:

(1) Receiving, identifying, and classifying notices of events which need immediate response by the carrier or notice to fire, police, or other appropriate public officials and communicating this information to appropriate carrier personnel for corrective action.

(2) Prompt and effective response to a notice of each type emergency, including fire or explosion occuring near or directly involving a pipeline facility accidental release of commodity from a pipeline facility, operational failure causing a hazardous condition, and natural disaster affecting pipeline facilities.

(3) Having personnel, equipment, instruments, tools, and material available as needed at the scene of an emergency.

(4) Taking necessary action, such as emergency shutdown, or pressure reduction, to minimize the volume of hazardous material that is released from any section of a pipeline system in the event of a failure.

(5) Control of released commodity at an accident scene to minimize the hazard, including possible intentional ignition in the cases of flammable highly volatile liquid.

(6) Minimization of public exposure to injury and probability of accidental ignition by assisting with evacuation of residents and assisting with halting traffic on roads and railroads in the affected area, or taking other appropriate action.

(7) Notifying fire, police, and other appropriate public officials of liquid pipeline emergencies and coordinating with them preplanned and actual responses during an emergency, including additional precautions necessary for an emergency involving a pipeline system transporting a highly volatile liquid.

(8) In the case of failure of a pipeline system transporting a highly volatile liquid, use of appropriate instruments to assess the extent and coverage of the vapor cloud and determine the hazardous areas.

(9) Providing for a post accident review of employee activities to determine whether the procedures were effective in each emergency and taking correction action where deficiencies are found.

4. 195.402 General requirements.

(a) Each carrier shall establish and maintain current written procedures;

(1) To ensure the safe operation and maintenance of its pipeline system in accordance with this Part during normal operations.

(2) To be followed during abnormal operations and

emergencies.

(b) No carrier may operate or maintain its pipeline systems at a level of safety lower than that required by this subpart and the procedures it is required to establish under paragraph (a) of this section.

(c) Whenever a carrier discovers any condition that could adversely affect the safe operation of its pipeline system it shall correct it within a reasonable time. However, if the condition is of such a nature that it presents an immediate hazard to persons or property, the carrier may not operate the affected part of the system until it has corrected the unsafe condition.

(d) Except as provided in 195.5, no carrier may operate any part of a pipeline system upon which construction was begun after March 31, 1970, or in the case of offshore pipelines located between a production facility and a carrier's trunkline reception point, after July 31, 1977, unless it was designed and constructed as required by this part.

5. 195.403 Training.

(a) Each carrier shall establish and conduct a continuing training program to instruct operating and maintenance personnel to;

(1) Carry out the operating and maintenance, and emergency procedures established under 195.402 that relate to their assignments;

(2) Know the characteristics and hazards of the commodities transported, including, in the case of flammable HVL, flammability of mixtures with air, oderless vapors, and water reactions;

(3) Recognize conditions that are likely to cause emergencies, predict the consequences of facility malfunctions or failures and commodity spills, and to take appropriate corrective action;

(4) Take steps necessary to control any accidental release of commodity and to minimize the potential for fire, explosion, toxicity, or environmental damage;

(5) Learn the proper use of firefighting procedures and equipment, fire suits, and breathing apparatus by utilizing, where feasible, a simulated pipeline emergency condition; and

(6) In the case of maintenance personnel, to safely repair facilities using appropriate special precautions, such as isolation and purging, when highly volatile liquids are involved.

(b) At intervals of not more than 1 year each carrier shall;

(1) Review with personnel their performance in meeting the objectives of the training program set forth in paragraph (a) of this section; and

(2) Make appropriate changes to the training program as necessary to insure that it is effective.

(c) Each carrier shall require and verify that its supervisors maintain a thorough knowledge of that portion of the procedures established under 195.402 for which they are responsible to insure compliance.

6. 195.101 Maps and records.

(a) Each carrier shall maintain current maps and records

of its pipeline systems that include at least the following information:

(1) Location and identification of all major facilities.

(2) All crossings of public roads, railroads, rivers, buried utilities, and foreign pipelines.

(3) The maximum operating pressure of each pipeline.

(4) The diameter, grade, type, and nominal wall thickness of all pipe.

(b) Each carrier shall maintain daily operating records that indicate the discharge pressures at each pump station and any unusual operations of a facility. The carrier shall retain these records for at least 3 years.

(c) Each carrier shall also maintain for the useful life of that part of the pipeline system to which they relate, records that include the following:

(1) The date, location, and description of each repair made to its pipeline systems.

(2) A record of each inspection and each test required by this subpart.

7. 195.406 Maximum operating pressure.

(a) Except for surge pressures and other variations from normal operations, no carrier may operate a pipeline at a pressure that exceeds any of the following:

(1) The internal design pressure of the pipe determined in accordance with 195.106.

(2) The design pressure of any other component of the pipeline.

(3) Eighty percent of the test pressure for any part of the pipeline which has been hydrostatically tested under Subpart E of this part.

(4) Eighty percent of the factory test pressure or of the prototype test pressure for any individually installed component which is excepted from testing under 195.304.

(b) No carrier may permit the pressure in a pipeline during surges or other variations from normal operations to exceed 110 percent of the operating pressure limit established under paragraph (a) of this section. Each carrier must provide adequate controls and protective equipment or control the pressure within this limit.

8. 195.408 Communications.

(a) Each carrier must have a communication system to provide for the transmission of information needed for the safe operation of its pipeline system.

(b) The communication system required by paragraph (a) of this section must, as a minimum, include means for;

(1) Monitoring operational data as required by 195.402 (c)(9);

(2) Receiving notices from carrier personnel, the public, and public authorities of abnormal or emergency conditions and sending this information to appropriate personnel or government agencies for corrective action;

(3) Conducting two-way vocal communication between a control center and the scene of abnormal operations and

emergencies; and

(4) Providing communication with fire, police, and other appropriate public officials during emergency conditions, including a natural disaster.

9. 195.410 Line Markers.

(a) Except as provided in paragraphs (b) and (c) of this section, each carrier shall place and maintain line markers over each buried line in accordance with the following;

(1) Markers must be located at each public road crossing, at each railroad crossing, and in sufficient number along the remainder of each buried line so that its location is accurately known.

(2) The marker must state at least the following; "Warning" followed by the words "Petroleum (or the name of the commodity transported) Pipeline" (in lettering at least 1 inch high with an approximate stroke of one-quarter inch on a background of sharply contrasting color), the name of the carrier and a telephone number (including area code) where the carrier can be reached at all times. Markers at navigable waterway crossings must also contain the words "Do Not Anchor or Dredge" with lettering not less than 12 inches high with an approximate stroke of 1 3/4 inches on a background of sharply contrasting color.

(b) Line markers are not required in heavily developed urban areas such as downtown business centers where -

(1) The placement of markers is impracticable and would not serve the purpose for which markers are intended; and

(2) The local government maintains current sub-

structure records.

(c) Line markers that have been installed before April 1, 1970, may be used until April 1, 1975.

(d) Each carrier shall provide line marking at locations where the line is above ground in areas that are accessible to the public.

10. 195.412 Inspection of rights-of-way and crossings under navigable waters.

(a) Each carrier shall, at intervals not exceeding 2 weeks, inspect the surface conditions on or adjacent to each pipeline right-of-way.

(b) Except for offshore pipelines, each carrier shall, at intervals not exceeding 5 years, inspect each crossing under navigable waterway to determine the condition of the crossing.

11. 195.414 Cathodic protection.

(a) After March 31, 1973, no carrier may operate a pipeline that has an external surface coating material, unless that pipeline is cathodically protected. This paragraph does not apply to tank farms and buried pumping station piping.

(b) Each carrier shall electrically inspect each bare pipeline before April 1, 1975, to determine any areas in which active corrosion is taking place. The carrier may not increase its established operating pressure on a section of bare pipeline until the section has been so electrically inspected. In any areas where active corrosion is found, the carrier shall provide cathodic protection. Section 195.416 (f) and (g) applies to all corroded pipe that is found.

(c) Each carrier shall electrically inspect all tank

farms and buried pumping station piping before April 1, 1973, as to the need for cathodic protection, and cathodic protection shall be provided where necessary.

(d) Notwithstanding the deadline for compliance in paragraphs (a), (b), and (c) of this section, this section does not apply to offshore pipelines located between a production facility and a carrier's trunkline reception point until August 1, 1977.

12. 195.416 External corrosion control.

(a) Each carrier shall, at intervals not exceeding 12 months, conduct tests on each underground facility in its pipeline systems that is under cathodic protection to determine whether the protection is adequate.

(b) Each carrier shall maintain the test leads required for cathodic protection in such a condition that electrical measurements can be obtained to ensure adequate protection.

(c) Each carrier shall, at intervals not exceeding 2 months, inspect each of its cathodic protection rectifiers.

(d) Each carrier shall, at intervals not exceeding 5 years, electrically inspect the bare pipe in its pipeline system that is not cathodically protected and must study leak records for that pipe to determine if additional protection is needed.

(e) Whenever buried pipe is exposed for any reason, the carrier shall examine the pipe for evidence of external corrosion. If the carrier finds that there is active corrosion, that the surface of the pipe is generally pitted, or that corrosion has caused a leak, it shall investigate further to determine the extent of the corrosion.

(f) Any pipe that is found to be generally corroded so that the remaining wall thickness is less than the minimum thickness required by the pipe specification tolerances must either be replaced with coated pipe that meets the requirements of this part or, if the area is small, must be repaired. However, the carrier need not replace generally corroded pipe if the operating pressure is reduced to be commensurate with the limits on operating pressure specified in this subpart, based on the actual remaining wall thickness.

(g) If isolated corrosion pitting is found, the carrier shall repair or replace the pipe unless -

(1) The diameter of the corrosion pits is less than the nominal wall thickness as measured at the surface of the pipe, and;

(2) The remaining wall thickness at the bottom of the pits is at least 70 percent of the nominal wall thickness.

(h) Each carrier shall clean, coat with material suitable for the prevention of atmospheric corrosion, and, maintain this protection for each component in its pipeline system that is exposed to the atmosphere.

13. 195.418 Internal corrosion control.

(a) No carrier may transport any commodity that would corrode the pipe or other components of its pipeline system, unless it has investigated the corrosive effect of the commodity on the system and has taken adequate steps to mitigate corrosion.

(b) If corrosion inhibitors are used to mitigate internal corrosion the carrier shall use inhibitors in sufficient

quantity to protect the entire part of the system that the inhibitors are designed to protect and shall also use coupons or other monitoring equipment to determine their effectiveness.

(c) The carrier shall, at intervals not exceeding 6 months, examine coupons or other types of monitoring equipment to determine the effectiveness of the inhibitors or the extent of any corrosion.

(d) Whenever any pipe is removed from the pipeline for any reason, the carrier must inspect the internal surface for evidence of corrosion. If the pipe is generally corroded such that the remaining wall thickness is less than the minimum thickness required by the pipe specification tolerances, the carrier shall investigate adjacent pipe to determine the extent of the corrosion. The corroded pipe must be replaced with pipe that meets the requirements of this part or, based on the actual remaining wall thickness, the operating pressure must be reduced to be commensurate with the limits on operating pressure specified in this subpart.

14. 195.420 Valve maintenance.

(a) Each carrier shall maintain each valve that is necessary for the safe operation of its pipeline systems in good working order at all times.

(b) Each carrier shall, at intervals not exceeding 6 months, inspect each main line valve to determine that it is functioning properly.

(c) Each carrier shall provide protection for each valve from unauthorized operation and from vandalism.

15. 195.422 Pipeline repairs.

(a) Each carrier shall, in repairing its pipeline systems, insure that the repairs are made in a safe manner and are made so as to prevent damage to persons or property.

(b) No carrier may use any pipe, valve, or fitting for replacement in repairing pipeline facilities, unless it is designed and constructed as required by this part.

16. 195.424 Pipe movement.

(a) No carrier may move any line pipe, unless the pressure in the line section involved is reduced to not more than 50 percent of the maximum operating pressure.

(b) No carrier may move any pipeline containing highly volatile liquids where materials in the line section involved are joined by welding unless -

(1) Movement when the pipeline does not contain highly volatile liquids is impractical;

(2) The procedures of the carrier under 195.402 contain precautions to protect the public against the hazard in moving pipelines containing highly volatile liquids, including the use of warnings, where necessary, to evacuate the area close to the pipeline; and

(3) The pressure in that line section is reduced to the lower of the following;

(i) Fifty percent or less of the maximum operating pressure; or

(ii) The lowest practical level that will maintain the commodity in a liquid state with continuous flow, but not less than 50 p.s.i.g above the vapor pressure of the

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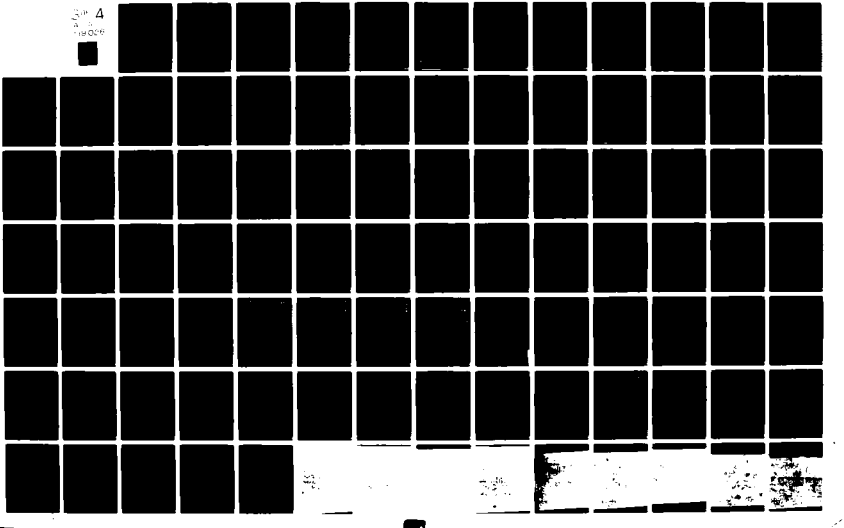


commodity.

(c) No carrier may move any pipeline containing highly volatile liquids where materials in the line section involved are not joined by welding unless -

(1) The carrier complies with paragraphs (b) (1) and (2) of this section; and

(2) That line section is isolated to prevent the flow of commodity.

17. 195.426 Scraper and sphere facilities.

No carrier may use a launcher or receiver that is not equipped with a relief device capable of safely relieving pressure in the barrel before insertion or removal of scrapers or spheres. The carrier must use a suitable device to indicate that pressure has been relieved in the barrel or must provide a means to prevent insertion or removal of scrapers or spheres if pressure has not been relieved in the barrel.

18. 195.428 Overpressure safety devices.

(a) Except as provided in paragraph (b) of this section, each carrier shall at intervals not exceeding 12 months, or 6 months in the case of pipelines used to carry highly volatile liquids, inspect and test each pressure limiting device, relief valve, pressure regulator, or other item of pressure control equipment to determine that it is functioning properly, is in good mechanical condition, and is adequate from the standpoint of capacity and reliability of operation for the service in which it is used.

(b) In the case of relief valves on pressure storage vessels containing highly volatile liquids, each carrier shall

test each valve at intervals not exceeding 5 years.

19. 195.430 Firefighting equipment.

Each carrier shall maintain adequate firefighting equipment at each pump station, terminal, 33 and tank farm. The equipment must be -

(a) In proper operating condition at all times.

(b) Plainly marked so that its identity as firefighting equipment is clear; and

(c) Located so that it is easily accessible during a fire.

20. 195.432 Storage vessels.

Each carrier shall, at intervals not exceeding 12 months inspect each storage vessel (including atmospheric and pressure tanks).

21. 195.434 Signs.

Each carrier shall maintain signs visible to the public around each pumping station, terminal, or tank farm. Each sign must contain the name of the carrier and an emergency telephone number to contact.

22. 195.436 Security of facilities.

Each carrier shall provide protection for each pumping station, terminal and tank farm and other exposed facility (such as scraper traps) from vandalism and unauthorized entry.

23. 195.438 Smoking or open flames.

Each carrier shall prohibit smoking and open flames in each pump station area and each terminal or tank farm area where there is a possibility of the leakage of a flammable commodity or of the presence of flammable vapors.

24. 195.440 Public education.

Each carrier shall establish a continuing educational program to enable the public, appropriate government organizations, and persons engaged in excavation related activities to recognize a liquid pipeline emergency and to report it to the carrier or the fire police, or other appropriate public officials. The program must be conducted in English and in other languages commonly understood by a significant number and concentraion of non-English speaking population in the carriers operating areas.

DEPARTMENT OF TRANSPORTATION
Office of Pipeline Safety Operations
PIPELINE CARRIER ACCIDENT REPORT

FORM APPROVED
BUDGET BUREAU NO.
04-R5720

Instructions →

Complete in duplicate. If the space provided for any question is not adequate, attach an additional sheet. Definition of a reportable accident is stated in the Code of Federal Regulations, Title 49, Part 195, Subpart B. File both copies of this report within 15 days after discovery of the accident with the Director, Office of Pipeline Safety Operations, Department of Transportation, Washington, D. C. 20590. Detailed instructions for preparing this form are found in Part 195, Subpart B, Section 195.56. Specimen copies of this form will be supplied upon request without charge. Additional copies may be reproduced using the same format and size. This report is required by 49 CFR Section 195.54. Failure to report can result in $1,000 fine or imprisonment for 1 year as provided in 18 U.S.C. 832.

A. Carrier Information

1. NAME OF CARRIER

2. PRINCIPAL BUSINESS ADDRESS

B. Time and Location of Accident

1. DATE (Month, Day, Year)
2. HOUR ☐ AM ☐ PM
3. LOCATION (State, County, City)
4. PART OF CARRIER'S SYSTEM INVOLVED
☐ LINE PIPE ☐ PUMPING STATION ☐ DELIVERY POINT
☐ TANK FARM ☐ OTHER (specify) _____
5. PHYSICAL LOCATION (If location is near public or private buildings, or other significant landmarks such as highways or railroads, attach a sketch or drawing showing relationship of accident location to these landmarks)

C. Origin of Liquid or Vapor Release

☐ PIPE ☐ GIRTH WELD ☐ LONGITUDINAL WELD ☐ PUMP ☐ VALVE ☐ SCRAPER TRAP
☐ METER OR PROVER ☐ TANK ☐ WELDED FITTING ☐ BOLTED FITTING
☐ SAMPLE HOUSE ☐ HAY TANK ☐ STRAINER OR FILTER ☐ OTHER (Specify) _____

D. Cause of Accident

☐ CORROSION ☐ DEFECTIVE WELD ☐ INCORRECT OPERATION BY CARRIER PERSONNEL
☐ DEFECTIVE PIPE ☐ EQUIPMENT RUPTURING LINE ☐ OTHER (specify) _____

E. Death or Injury

1. NUMBER OF PERSONS KILLED		2. NUMBER OF PERSONS INJURED	
CARRIER EMPLOYEES	NON-EMPLOYEES	CARRIER EMPLOYEES	NON-EMPLOYEES

F. Property Damage

1. CARRIER'S DAMAGE (Physical property damaged)
$
2. ITEMS DAMAGED
3. OTHER PROPERTY DAMAGE
$
4. ITEMS DAMAGED

G. General Information

1. Commodity being transported at time of accident	2. Estimated loss due to accident	3. Year facility Installed (excluding pipe)	4. Was there a fire?	5. Was there an explosion?
	Barrels		☐ Yes ☐ No	☐ Yes ☐ No

Instructions → Answer sections H, I or J only if they apply to the particular accident being reported.

H. Occurred in the Pipe

1. Nominal Diameter	2. Wall Thickness	3. Grade	4. Year of Installation	5. Condition When Installed	6. Type of Joint
in.	in.		☐ Before 1920 ☐ 1920-30 ☐ 1930-5 ☐ After 1935 (specify yr.) _____	☐ New ☐ Reconditioned	☐ Weld ☐ Couple ☐ Threaded

7. Configuration at Point of Accident	8. Pipe Was	9. Pipe Was
☐ Straight ☐ Sag ☐ Overbend ☐ Sidebend	☐ Coated ☐ Not Coated	☐ Above ☐ Below Ground

10. Cover, if below ground	11. Design Pressure	12. Pressure at time & location of accident	13. Had there been a pressure test on system?
in.	psig	psig	☐ Yes ☐ No

14. If 13. is Yes, Medium Used	15. Duration of Test	16. Maximum Test Pressure	17. Date of Latest Test
☐ Water ☐ Petroleum ☐ Air	Hrs.	psig	

I. Caused by Corrosion	1. Type of Corrosion ☐ Internal ☐ External	2. Facility Coated ☐ Yes ☐ No	3. Facility Under Cathodic Protection? ☐ Yes ☐ No	4. Time Between Corrosion Tests: Months	5. Type of Test Used
J. Caused by Equipment ...cturing ...peline	1. Distance to Closest Line Marker	2. Information on Marker			3. Length of Time Between Patrol on Section: Days

ACCOUNT OF ACCIDENT BY RESPONSIBLE OFFICIAL OF CARRIER

NAME AND TITLE OF CARRIER OFFICIAL FILING THIS REPORT	TELEPHONE NO. (INCLUDE AREA CODE)	DATE

SECTION G-1

THREE (3) POL LINES LOCATED IN THE LOWER RED HILL TUNNEL FROM THE RED HILL STORAGE TANKS TO THE PEARL HARBOR NAVAL BASE

SECTION G-1

THREE (3) POL LINES LOCATED IN THE LOWER RED HILL TUNNEL FROM THE RED HILL STORAGE TANKS TO THE PEARL HARBOR NAVAL BASE

SECTION G-1

SUMMARY

1. Conclusions:

The external surface of all three (3) POL pipelines in the Red Hill Tunnel are experiencing some type of coating damage and corrosive attack, due to ground water leaks in the 6" gunite coating of the tunnel.

Several of the steel structural support members are also experiencing severe corrosion due to water leakage in the tunnel.

The constant dripping of ground water and the high evaporation rate has caused concentrated corrosion cells on the exterior of the pipelines.

2. Recommendations:

The corrosion damaged areas on three (3) POL pipelines should be re-coated, as recommended. The annular spaces, at the 6" bulkhead/wall penetration in the new tank area, should be repaired, as recommended. The existing galvanized sheet steel "umbrellas" should be replaced with non-metallic materials. A structural/civil engineer should determine to what extent corrosion damage has effected the structural support members in the tunnel. A corrosion evaluation survey should be performed on the 32" Ø water line in the tunnel. Because of the leaks, a corrosion survey should be performed on the twenty (20) underground storage tankliners and associated underground piping in the storage tank area.

SECTION G-1

THREE (3) POL LINES LOCATED IN THE LOWER RED HILL TUNNEL FROM THE RED HILL STORAGE TANKS TO THE PEARL HARBOR NAVAL BASE

INTRODUCTION

A corrosion evaluation survey was conducted on the three (3) POL lines in the Lower Red Hill Tunnel from the Red Hill Storage Tanks to the Pearl Harbor Naval Base, upon authorization from Commander A.L. Moyle, C.E.C., Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii. The Admendment of Modification Contract N62742-81-C-0006/P00002 was dated January 12, 1982.

Engineers from Pacific Corrosion Research, Inc. reported to Mr. Fred Nakamura, Project Design Engineer and Mr. Jim Gammon, Superintendent of the Fuel Department, on May 10, 1982, to start the field portion of this project. During the actual field survey, Mr. Albert Wong of the Fuel Department provided assistance and escort, when necessary.

1. Description:

The pipelines under consideration during this survey are the 16" Ø, 18" Ø and the 32" Ø POL lines from the Red Hill Storage Tanks to the receiving pump station at the Pearl Harbor Naval Base. These are welded steel pipelines, of varying wall thickness and various coatings. The 16" Ø, 18" Ø and 32" Ø POL lines are supported on H-Beam supports overhead in the storage tank area of the Lower Red Hill Tunnel. Between the receiving pumphouse and the beginning of the storage tank area, the 16" Ø and 18" Ø lines are supported on H-Beams and angle-iron support racks, with the 16" Ø above the 18" Ø line. The 32" Ø line is supported on concrete saddles, which are marked and numbered by Navy personnel from #1 to #638, from the storage tank area to the pumphouse respectively. These saddle numbers are referred to, extensively,

in the tables and it should be noted that several discrepancies seem to exist between the painted numbers and the actual number of saddles. Therefore, the painted numbers on the saddles will apply in the report.

In the area of the storage tanks, since there are no saddle numbers, each H-Beam support was assigned a number from #1 to #94 with #1 starting at Storage Tanks #19 and #20. See Drawing #6537, Table No. XXIII-B, for exact location of these supports.

All three (3) lines have various coatings on them. The coatings encountered are as follows:

A. Vinyl/acrylic.
B. Primer, coal-tar impregnated fiberglass, coal-tar enamel and silver paint.
C. Coal-tar primer (coal-tar enamel), impregnated fiberglass pipeline felt. (Note: This type of coating was principally used as a repair to previously painted only coatings)

The tunnel, in which these pipelines are located is a steel arch supported type with a 6" gunite coating. In areas where the tunnel is under existing roads or highways, additional support is provided by both steel arches and steel H-Beam stringers. This additional support seems to have been very effective in reducing the number of cracks in the gunite surface, thereby, reducing the number of water leaks in these areas. It should be noted however, portions of these additional supports were installed as recently as two to three years ago and therefore have no real effect on the integrity of the gunite coating, as it relates to the cracks and water leaks. Only the supports installed, as part of the original construction, seem to have kept the cracks and water leaks within the gunite, to a minimum. Also, the original supports appear to have a superior coating applied to them while the newly installed supports appear to have a minimal and in-effective phosphated type coating.

In numerous areas along the three (3) pipelines, there are galvanized sheet steel "umbrellas" suspended from the top of the tunnel over the pipeline. These are installed to keep ground water, which leaks from the top of the tunnel, away from the pipe surface.

2. Field Work and Evaluation of Data:

A. General.

Available drawings were provided by Mr. Fred Nakamura, Project Design Engineer, Code 102 and Mr. Edwin Katada, Fuel Department Engineer, N.S.C., during this survey.

The three POL pipelines and associated laterals in the Lower Red Hill Tunnel can be divided into four primary sections as follows:

1) From H-Beam #1 to H-Beam #11 in the area of the New Storage Tanks #17 thru #20.

2) From H-Beam #12 to H-Beam #94 in the area of Storage Tanks #1 thru #16.

3) From Support Saddle #1 to Support Saddle #638; i.e. from the end of the storage tank area to the receiving pumphouse.

4) Cross lateral piping from each storage tank to main piping in the tunnel. Ten (10) cross laterals; two (2) tanks at each crossing.

B. Inspection of Pipelines.

Engineers from Pacific Corrosion Research, Inc. along with Mr. Albert Wong of the Fuel Department, inspected the above pipelines with respect to corrosion damage including; deterioration, severity of rusting, pitting damage, repair attempts and causes of corrosion activity.

The observed results of these inspections are as follows:

1) H-Beam #1 to H-Beam #11 - The piping in this area traverses Zones #4, #5, #6 and #7; serving Storage Tanks #17 thru #20. Between each zone is a 6" concrete bulkhead wall, which the pipeline penetrates. At each of these penetrations, the pipeline is sleeved with a ¼" steel casing, approximately 1½"-2" larger in diameter than the pipe itself. The annular space between the pipe and the casing is filled with fiberglass insulation. Since there are several heavy water leaks at the top of the tunnel, at each of these bulkheads, the casing and pipe at each of these locations are experiencing severe corrosion damage. This is due to the fact that the fiberglass insulation acts as a sponge, absorbing and retaining moisture. Since the water leaks seem to be constant, the insulation is always moist.

Throughout this entire section, there are numerous moderate to severe water leaks at the top of the tunnel. At almost everyone of the leak locations, an attempt has been made to divert the water by installation of a galvanized sheet steel "umbrella". However, the effectiveness of these umbrellas in this area, are at best, minimal. There are several areas where there is extensive coating damage and severe rusting, however, no serious pitting damage was noted. Also, it should be pointed out, that although the coating may appear to be acceptable in many areas, in reality, there is no effective bond between the coating and the pipeline, thereby allowing moisture entrapment to occur between the pipe surface and the coating. Inspection of all the pipe surfaces, at these locations, was not feasible because all the coating would have to be damaged or removed.

It was noted during this inspection, there was major corrosion damage to the first vertical H-Beam, located on the west side of the lateral piping at Storage Tank #19. Portions of the web thickness have been reduced as much as 50%. This is due to water running down along the web face from a leak above the support. The type of corrosion observed is known as de-lamanation, where metal actually flakes off in a sheet like manner. It should be noted that not all locations of corrosion activity could be inspected or detailed due to the subjectiveness of this survey. The major areas of concern are detailed in the tables and general patterns and trends discussed. See Drawing No. 6537 and Table No. XXIII-A, located in the appendix of this report.

2) From H-Beam #12 to H-Beam #94 - The piping in this area serves Storage Tanks #1 thru #16. The three (3) pipelines are approximately 6' above the tunnel floor on H-Beam support racks, from Station 43+19 to Station 27+05.

In this area of the tunnel, there are several sections of piping that exhibit severe corrosive attack.

a. The 16" Ø and 18" Ø piping between supports #18 and #19 are being subjected to a severe ground water leak from the top of the tunnel. The severity of this leak is such that water can be observed dripping in an almost continuous stream from the ceiling of the tunnel. This has caused serious coating damage and deterioration, severe rust damage and moderate pitting to the pipeline. The surfaces of these lines are kept wetted at all times.

b. The first vertical H-Beam support columns on both sides of the lateral piping at Tanks #15 and #16 and the horizontal H-Beam at Support #19 have seriously deteriorated due to corrosion damage. The extent is such that as much as 90% of the web thickness has been lost to corrosion. Again, this is a de-laminating type of corrosive attack due to a constant water flow across and down the web faces of both horizontal and vertical structural support. Throughout the above described area, attempts to divert the ground water leaks have been made by installing galvanized sheet steel "umbrellas" above the piping. However, most of these have also experienced severe corrosion damage to the point they are no longer effective.

c. The first vertical H-Beam support cloumn, north of Support #37, at Tank #11, is severely corroded. The flange thickness was measured with a micrometer at a non-corroded area and found to be .437 in. Measurements obtained at the corroded areas were as low as .125 in. This corrosion damage is caused by ground water leaking down the support column at a significant rate.

d. There is very serious corrosion damage to the bolted flanges on both the 18" Ø and the 32" Ø pipe between H-Beams #44 and #45. On both flanges, approximately 60% to 70% of the nut and bolt assemblies have deteriorated, with material loss as high as 75% on some of the nuts. The coating on both pipes adjacent to the flange faces has been damaged to the point there is no longer an effective bond between the coating and the pipe surface.

The above described damage is due to a severe ground water leak above both flanges. The magnitude of

these leaks is such that the pipe and flange surfaces are kept wetted at all times.

e. On the three POL lines from H-Beam #46 to H-Beam #94, numerous areas of coating damage, heavy rusting and moderate pitting were observed. There are also numerous ground water leaks at the top of the tunnel throughout this area that are contributing significantly to this corrosion damage. For exact locations and details of these leaks and corrosion damaged areas, see Drawing No. 6537 , Table No. XXIII-B located in the appendix of this report.

3) From Saddle #1 to Saddle #638 - The three POL pipelines in this area go from the end of the storage tank section to the receiving pumphouse (Bldg. 59). The 32" Ø pipe is supported on concrete saddles, spaced approximately 25' apart. The 16" Ø and 18" Ø pipes are supported on angle-iron racks above the 32" Ø line. These racks are located between the concrete saddles and are also spaced approximately 25' apart. The three POL pipelines also pass through concrete bulkheads or anchors and doors.

This section of piping exhibits several significant areas of corrosion damage, leak repair, coating damage and ground water leakage.

a. Between Saddle #44 and #45 there is a 5' concrete anchor in which all three POL lines penetrate. Corrosive attack in the form of severe pitting has occured at the interface of the concrete anchor and the pipeline on all three lines between Saddle #44 and the concrete anchor. Pits as deep as 3/16" were measured on all three lines using a standard pit-depth gauge. Pits of this depth represent a loss from 50% to 75% of the original

wall thickness of the pipe, depending on the pipe size.

This damage has occured due to the severity of ground water leaks from the top of the tunnel. The water leaks down the face of the concrete anchor and accumulates on the surface of the pipe. It should be noted that the above described pitting damage has occured between 2" and 4" back from the concrete anchor and only on the top surface of the piping. The coating on all three lines at this location is heavily damaged due to ground water leakage.

Approximately 30" back from the concrete anchor, there is a half circle steel plate repair patch welded on the 18" Ø pipe. This patch was required because of an external leak which developed due to corrosion from a ground water leak above the pipe.

b. Between Saddle #71 and #72 there is a 5' concrete anchor in which all three POL lines penetrate. Corrosion damage in the form of <u>severe pitting</u> has occured on the 16" Ø line approximately 4" out from the interface between #72 and the concrete anchor. Pitting as deep as 1/16" was measures, using a standard pit-depth gauge. This damage has been caused by a water leak at the top of the tunnel. The ground water seeps down the face of the concrete anchor and then flows onto the pipe surface where it accumulates. The coating is also severely damaged due to the ground water leakage and no longer provides adequate protection to the pipe surface.

c. Between Saddle #110 and Saddle #111 there is a 6" concrete wall/bulkhead which all three POL lines penetrate. At the present time there is no corro-

sion damage on the pipelines. However, the 16" Ø pipeline has recently had an external leak repaired with a full circle steel plate patch welded around the pipe in two sections. Where the 16" Ø pipeline penetrates the concrete bulkhead, approximately 3" of concrete was completely removed around the entire circumference of the pipe to facilitate this repair. It was noted that the reinforcing steel with the bulkhead did not touch the pipe surface. It was learned that a ground water leak from the top of the tunnel was the primary cause of corrision leak on the pipe. Also, it was learned the actual position of the leak was outside of the bulkhead penetration. The removal of the concrete from around the pipe was to facilitate insertion of the steel plate patch. It should be noted that there is a water leak at the top of the tunnel that seeps down the east face of the bulkhead and accumulates on the 16" Ø and 18" Ø pipe. Since this survey was conducted during the dry time of the year, one can only expect the magnitude of the leak to increase during the rainy season.

d. A bolted repair clamp was found on the 16" Ø pipeline at Saddle #141. It was learned that a corrosion leak occured on this line approximately two years ago and was repaired by using the above described clamp. The corrosion damage was caused by a severe ground water leak above the top of the pipe. This fuel leak is still prevalent at the present time.

Closer inspection of the repair clamp revealed that a slight leak exists at the bottom of this clamp. It was noted, there is a small amount of JP-5 fuel dripping from the bottom of this clamp. This fuel is dripping on the coating of the 18" Ø and 32" Ø

lines and causing coating damage.

e. Between Saddles #156 and #238, the overall condition of all three POL lines; with respect to coating, rusting and general corrosion damage; can be considered in the poor condition. Throughout the entire tunnel, there are numerous ground water leaks at both the top and the sides of the tunnel. A major portion of the coating on all lines has suffered serious damage due to the profusion of ground water leaks. Although no visible damage to the coating was noted in many areas, there is no longer an effective bond between the coating and the pipe surface at a majority of these locations. This is primarily due to moisture intrusion between the coating and pipe.

There is also numerous areas where severe rust and moderate pitting damage was observed.

Attempts to divert ground water leaks with the installation of galvanized sheet steel "umbrellas" have not been totally sucessful. The majority of these "umbrellas" are so severely corroded that they no longer effectively keep water off the pipeline surfaces. For exact locations and specific details, see Drawing No.6537, 6538 & 6539, Table No. XXIII-C, in the appendix of this report.

4) Ground Water Evaluation - The water sample obtained which was ground water percolating through a crack in the tunnel gunite ceiling, was brought back to the laboratory and analyzed. The analysis, Table No.XXIII-D, is included in the appendix of this report.

3. Conclusions:

Based on the field data obtained from the inspection of the three (3) POL pipelines within the Red Hill Tunnel, the following conclusions can be drawn:

The corrosion damage encountered on all the pipelines is primarily due to extensive ground water leaks at the top of the tunnel. These leaks occur at cracks and failures in the 6" gunite coating.

The magnitude of these leaks range from slight seepage to continuous dripping at some locations. The water can be considered to be moderately aggressive. The continued dripping on a ferrous structure and the excellent ventilation in the tunnel will rapidly evaporate water and leave a continuing build up of salts which will set up a concentration cell which will, in the presence of oxygen cause concentrated corrosion to a steel structure.

At the time of our investigation in May of 1982, the rainy season had past and although water was seeping into the tunnel, it was evident from the stalagtite formation, a much greater amount of water had been present in periods of the past. The corrrective action should be pursued in two directions. The first should be to keep the water from dripping on the pipe and supporting structures. The second should be to clean to bare metal, any areas where the coating has been damaged and coated as recommended. The supporting structures, after repairs and recommendations are made by a Navy structural engineer, should be cleaned and coated as recommended.

There have been numerous attempts to keep the water off the pipeline surface. The method used is to suspend a galvanized sheet steel "umbrella" from the top of the tunnel between the ceiling and the pipe as to divert the water off the pipe

surface. However, the success of these "umbrellas" has been at best, minimal. The majority of them are corroded to some degree and therefore offer little protection of the pipelines. Since the magnitude and the location of these ground water leaks are constantly changing due to seasonal changes, it is almost impossible to keep ahead of the leakage problem, by using steel sheeting.

There are areas where water leaks are minimal and corrosion damage is slight. The main reason for this is these area are located in portions of the tunnel where there is internal steel support bracing where the tunnel passes under highways and roads. This extra bracing has contributed greatly to the overall integrity of the gunite coating, especially in preventing cracks from forming in the gunite coating. This in turn minimizes the number and magnitude of ground water leakage. It is well to note, however, that only the areas where this internal steel support bracing was installed as part of the original construction of the tunnel, are relatively free of water leaks and corrosion damage. This area where internal bracing has been installed in the last two to three years seem to still have a high incidence of water leaks and corrosion damage. In fact, extensive corrosion damage was noted on the newer internal support bracing itself, in several areas.

There were two major types of coating damage observed during this survey. One type is actual physical deterioration of the coating, resulting in exposure of the pipeline surface to corrosive attack of the ground water leaks. The second type is where there is no visible damage to the coating, but the coating has disbonded from the pipe, thereby allowing moisture intrusion between the coating and the pipe.

The corrosion damage to the pipeline at these areas could not be accurately determined without complete removal of the disbonded coating.

There are several H-Beam supports within the storage tank area that are experiencing severe corrosion damage. This damage is caused by water leaks collecting and running along the surface of the H-Beam. Some of these supports have deteriorated to the point where their structural integrity is highly questionable.

During the course of this survey considerable corrosion damage was observed in the form of rust and pitting on the 32" Ø water line in the Red Hill Tunnel. Although this line was not in the scope of work of this contract, the majority of the damage is at the 2½" take-off valve on the top of this line, especially where the nipples are welded to the line. In several places water was observed leaking from these weld interfaces.

The attempts to repair the coating, where water leaks have caused damage, are not sufficient. A roofing type of felt wrap was used and in most cases installed with minimal surface preparation.

During this survey, several pipe-to-soil potential readings were obtained on the storage tank piping. These readings were in the -300 mv range and indicate definite corrosion activity, of steel encased in concrete, is being developed. Therefore, it must be assumed that a significant portion of repeated leaks in the tank steel liners are caused by external corrosion.

In general, it can be concluded that all of the rust damage and major pitting damage is the direct result of ground water leaks from the top of the tunnel. If corrective measures are not taken to alleviate this, corrosion damage will continue at an accelerated rate. It also should be noted, one major factor which has contributed significantly to keeping the corrosion rate at a high level. This factor is the overall superiority of the ventilation system. The

fact there is a constant and rapid changeover of the air within the tunnel causes rapid evaporation of the ground water on the pipelines and thereby leaves concentrated salts and the resulting corrosion cells active in a moist environment with adequate oxygen for the cells to be active.

4. Recommendations:

The combination of water leaks, coating damage and corrosion damage; together with the results of the field survey, indicate several approaches are necessary to mitigate these problems. Our recommendations are as follows:

a. All areas on the three POL lines that have sustained any coating damage as described in this report, should be re-coated in the following manner:

1) Remove all existing coating.
2) Power wire-brush pipe surface to clean metal, removing all oxide coatings.
3) Repair all serious pitting by filling with weld material.
4) Dry pipe surface with electric blowers, heat lamps or torch. Pipe surface MUST BE DRY for proper application of coating.
5) Prime entire pipe surface with a coal-tar primer.
6) Apply a butyl-rubber mastic type coating by the glove method. Apply mastic to a minimum thickness of 1/8".
7) Wrap pipeline with a fiberglass reinforced felt.
8) Finish by applying a 15-20 mil thick PVC (polyvinyl chloride) self adhering tape, 2" wide, half-lapped to a distance 4" beyond each end of the coating repair.

It is important that the pipeline surface is completely dry before applying any coating material. This is necessary in order to insure an effective bond of the coating to the pipe surface.

b. Where the pipeline penetrates the 6" concrete bulkhead /walls between Zone #4 & #5, Zone #5 & #6, Zone #6 & #7 and Zone #7 and the Gauging Area; the annular space between the 1/4" steel casing and the pipe surface should be repaired in the following manner:

1) Completely remove all existing fiberglass insulation now filling the annulus.
2) Thoroughly dry the inside space by use of electric blower, heat lamps or other suitable means.
3) Fill the annular space between the casing and the pipeline with an epoxy based caulking compound, of the fast curing type.

c. Replace any of the galvanized sheet steel "umbrellas" that are no longer effectively diverting leaking ground water off the pipeline surface.

1) The replacement umbrella shall be constructed of a non-metallic material, such as 1/16" PVC, fiberglass sheeting or similar material.
2) The material shall have a wide range of flexibility in order to conform to the necessary contours.
3) The new umbrellas should be suspended from the top of the tunnel and to be of sufficient length to provide complete protection to all three pipelines.
4) The width of the new umbrellas should not exceed 48".
5) The new umbrellas shall have a 1"-90° lip formed on each edge perpendicular to the pipeline to create a channel for run-off.

d. It is recommended that the corrosion damaged structural steel support beams and all other structural members, in Red Hill Tunnel, which are subjected to corrosive attack be inspected by a certified Structural/Civil Engineer, retained by the Navy and that a report as to their structural integrity and recommendations for their repair and/or replacement be provided.

e. It is recommended that a corrosion evaluation survey, similar in scope to this report, be performed on the 32" Ø water line in the Red Hill Tunnel.

f. It is recommended that a corrosion survey, to determine the extent of corrosion damage on the twenty Red Hill Storage Tanks and all associated piping, be performed.

CORROSION EVALUATION
THREE (3) POL PIPELINES, 16" Ø, 18" Ø & 32" Ø
LOWER RED HILL TUNNEL
TANKS #17 thru #20
TABLE NO. XXIII-A

SEE DRAWING # 6537

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #1	45+59	*	*	*
Concrete Bulkhead Between Zone 4 & Zone 5		The annular space between the pipe and the casing at the bulkhead penetration is filled with fiberglass insulation. Due to a water leak above, the casing and pipe are severely corroding because the insulation absorbs and holds the moisture.	Same condition as the 16" Ø	Same condition as the 16" Ø
H-Beam #4	44+97	Leak from top of tunnel, galvanized umbrella corroded, coating damage observed.	Same condition as the 16" Ø	Same condition as the 16" Ø
H-Beam #8	44+03	Rust, coating damage, water leak from top of tunnel	*	*
H-Beam #9	43+81	Rust, coating damage, water leak from top of tunnel.	*	*
Concrete Bulkhead Between Zone 5 & Zone 6		The annular space between the pipe and the casing at the bulkhead penetration is filled with fiberglass insulation. Due to a water leak above, the casing and pipe are severely corroding because the insulation absorbs and holds the moisture.	Same condition as the 16" Ø	Same condition as the 16" Ø

TABLE NO. XXIII-A

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #11	43+41	*	*	*
Concrete Bulkhead Between Zone 7 & Gauging Area	43+25	*	*	*

* NOTE: Where no comment is made as to the condition of the pipeline, no visible corrosion damage was apparent. However, since the coating may be disbonded at any of these locations, one should not assume the condition of the pipeline is acceptable with respect to corrosion damage.

CORROSION . ALUATION

THREE (3) POL PIPELINES, 16" Ø, 18" Ø & 32" Ø

LOWER RED HILL TUNNEL

TANKS #1 THRU #16

TABLE NO. XXIII-B

SEE DRAWING # 6537

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #12	43+19	*	*	*
H-Beam #13	42+97	*	*	*
H-Beam #14	42+73	*	*	*
H-Beam #15	42+50	*	*	*
H-Beam #16	42+28	*	*	*
H-Beam #17	42+04	*	*	*
H-Beam #18	41+81	*	*	*
H-Beam #19	41+60	Severe water leak from top of tunnel, coating damage, rust, slight pitting	Same as 16" Ø	*
H-Beam #20	41+41	*	*	*
H-Beam #21	41+19	*	*	*
H-Beam #22	40+97	*	*	*
H-Beam #23	40+73	*	*	*
H-Beam #24	40+50	*	*	*
H-Beam #25	40+28	*	*	Water leak from top of tunnel coating damage, galvanized umbrella partially corroded.

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #26	40+03	*	*	Water leak from top of tunnel coating damage, galvanized umbrella partially corroded.
H-Beam #27	39+81	*	*	Water leak from top of tunnel galvanized umbrella effectiv
H-Beam #28	39+60	*	*	*
H-Beam #29	39+41	*	Water leak from above, galvanized umbrella effective.	*
H-Beam #30	39+19	*	*	*
H-Beam #31	38+98	*	*	*
H-Beam #32	38+73	*	*	*
H-Beam #33	38+50	*	*	*
H-Beam #34	38+28	*	*	*
H-Beam #35	38+04	*	Water leak above, coating damage galvanized umbrella corroded through.	Same condition as 18" Ø
H-Beam #36	37+81	*	*	*
H-Beam #37	37+59	*	*	*
H-Beam #38	37+41	*	*	Water leak at top of tunnel, rust, coating damage.
H-Beam #39	37+19	*	*	*

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #40	36+98	Water leak from top of tunnel, galvanized umbrella effective	*	Water leak from top of tunnel rust, coating damage, galvanized umbrella partially corroded.
H-Beam #41	36+73	*	*	*
H-Beam #42	36+50	*	*	*
H-Beam #43	36+28	*	*	*
5' East of H-Beam #44	(36+08) 36+03	*	Severe water leak from top of tunnel. The bolted flange at this location is severely corroded, especially the nut & bolt assemblies. A major portion of the nuts have lost more than half of their material mass to corrosion. The coating on both sides of the flange has deteriorated to the point that an effective bond between the coating and the pipe no longer exists.	Severe water leaks from top of the tunnel. The bolted flange at this location is severely corroded. Approximately 70% of the nuts on the west side of the flange have severely deteriorated. Material loss on these nuts is as high as 75%. The coating on the pipe adjacent to the flange has deteriorated to the point that there is no longer an effective bond between coating and the pipe. The magnitude of the water leak is such that the flange and adjacent piping are kept wetted at all times. Severe pitting was also observed on the pipe surface (top & side) immediately adjacent to the west side of the flange.

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #45	35+81	Water leak at top of tunnel. Coating damage, rust and slight pitting observed. Coating has deteriorated to a point where an effective bond between pipe and coating no longer exists.	Same condition as 16" Ø	Same condition as 16" Ø
H-Beam #46	36+60	Water leak at top of tunnel. Coating damage, rust and slight pitting observed.	Water leak at top of tunnel. Very bad coating damage, rusting and some pitting.	Water leak at top of tunnel. Severe coating damage and rust observed. Coating deteriorated to a point that no effective exists between coating & pipe.
H-Beam #47	35+41	*	*	*
H-Beam #48	35+19	*	Slight coating damage & rusting on bottom.	Water leak at top of tunnel. Coating damage & some rusting. Galvanized umbrella severely corroded.
H-Beam #49	34+97	*	*	Some coating damage on bottom of pipe.
H-Beam #50	34+73	*	*	Severe coating damage and rusting on bottom of pipe.
H-Beam #51	34+50	*	*	*
H-Beam #52	34+29	*	*	Coating damage & rusting on bottom of pipe.
H-Beam #53	34+04	Coating damage, rust & slight pitting on bottom of pipe.	*	*

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #54	33+81	*	*	*
H-Beam #55	33+59	*	*	*
H-Beam #56	33+41	Water leak at top of tunnel. Slight coating damage, rust & pitting on bottom of pipe.	Same condition as 16" Ø	Same condition as 16" Ø
H-Beam #57	33+19	Coating damage on bottom of pipe.	Same condition as 16" Ø	Same condition as 16" Ø
H-Beam #58	32+96	*	Coating damage on bottom of pipe.	*
H-Beam #59	32+75	*	*	*
H-Beam #60	32+52	*	Water leak at top of tunnel. Coating damage observed.	*
H-Beam #61	32+28	*	*	*
H-Beam #62	32+03	*	*	*
H-Beam #63	31+81	*	*	Water leak at top of tunnel. Coating damage & rusting observed.
H-Beam #64	31+59	*	Coating damage & rusting on bottom of pipe.	Water leak at top of tunnel. Coating damage & slight rusting.
H-Beam #65	31+41	*	*	*
H-Beam #66	31+20	Water leak at top of tunnel. Coating damage & rust.	Slight coating damage on bottom of pipe.	Same condition as 18" Ø

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #67	30+96	*	Heavy coating damage, rust & slight pitting on bottom of pipe.	*
H-Beam #68	30+75	Severe coating damage & corrosion noted.	Coating damage, rust & slight pitting on bottom pipe.	Same condition as 18" Ø
H-Beam #69	30+50	*	*	*
H-Beam #70	30+26	*	*	Water leak at top of tunnel. Coating damage & rust. Galvanized umbrella partially corroded.
H-Beam #71	30+05	*	Coating damage & rusting on bottom of pipe.	*
H-Beam #72	29+90	*	*	*
H-Beam #73	29+78	Water leak from top of tunnel. Coating damage noted.	Same condition as 16" Ø	Same condition as 16" Ø
H-Beam #74	29+68	Water leak from top of tunnel. Heavy coating damage & rusting observed.	Same condition as 16" Ø	Same condition as 16" Ø
H-Beam #75	29+59	*	Water leak at top of tunnel. Coating damage & rusting on bottom of pipe.	Slight coating damage on bottom of pipe.
H-Beam #76	29+41	*	Water leak at top of tunnel. Severe coating damage, rust & slight pitting noted.	Water leak at top of tunnel. Severe coating damage, rust & slight pitting on bottom of pipe.
H-Beam #77	29+32	Water leak at top of tunnel. Coating damage & rust on bottom of pipe.	*	Same condition as 16" Ø

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #78	29+22	*	Water leak from top of tunnel. Coating damage & rust on bottom of pipe.	*
H-Beam #79	29+10	*	*	Water leak at top of tunnel. Coating damage,rust & slight pitting on bottom of pipe.
H-Beam #80	28+95	*	*	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom of pipe.
H-Beam #81	28+80	*	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom if pipe.	*
H-Beam #82	28+65	*	Water leak at top of tunnel. Slight coating damage & rust on bottom of pipe.	Same condition as 18" Ø
H-Beam #83	28+50	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom of pipe.	Same condition as 16" Ø	Water leak at top of tunnel. Coating damage, rust & slight pitting noted.
H-Beam #84	28+35	*	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom of pipe.	*
H-Beam #85	28+20	Water leak at top of tunnel. Heavy coating damage.	Water leak at top of tunnel. Coating damage and rust on bottom of pipe.	Same condition as 16" Ø
H-Beam #86	28+05	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom of pipe.	Same condition as 16" Ø	*

TABLE NO. XXIII-B

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
H-Beam #87	27+90	*	*	*
H-Beam #88	27+78	Water leak at top of tunnel. Moderate coating damage observed.	Water leak at top of tunnel. Coating damage, rust & slight pitting on bottom of pipe.	*
H-Beam #89	27+68	*	Water leak at top of tunnel. Coating damage on bottom of pipe.	*
H-Beam #90	27+59	*	*	*
H-Beam #91	27+41	Water leak at top of tunnel. Coating damage on bottom of pipe.	*	*
H-Beam #92	27+32	*	Water leak at top of tunnel. Coating damage on bottom of pipe.	Same condition as 18" Ø
H-Beam #93	27+23	*	Water leak at top of tunnel. Coating damage on bottom of pipe.	Same condition as 18" Ø
H-Beam #94	27+05	Water leak at top of tunnel. Coating damage and rust on bottom of pipe.	Water leak at top of tunnel. Heavy coating damage noted.	Same condition as 16" Ø

*NOTE: Where no comment has been made as to the condition of the pipeline, no visible corrosion damage was apparent. However, since the coating may be disbonded at any of these locations, one should not assume the condition of the pipeline is acceptable with respect to corrosion damage.

CORROSION EVALUATION

THREE (3) POL PIPELINES, 16" Ø, 18" Ø & 32" Ø

LOWER RED HILL TUNNEL

SADDLE #1 THRU #638

TABLE NO. XXIII-C

SEE DRAWINGS # 6537, 6538 & 6539

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #1		*	*	*
Saddle #2	26+04.56	*	*	*
Saddle #3	25+98.06	*	*	*
Saddle #4	25+82.8	*	*	*
Saddle #5	25+65	*	*	*
Saddle #6	25+41.31	*	*	*
Saddle #7	25+15.96	*	*	*
5' Concrete Anchor	24+89	Water leak at top of tunnel. Slight coating damage & rust on west side.	*	*
Saddle #8	24+65	*	*	*
Saddle #9	24+40	*	*	*
Saddle #10	24+14	*	*	*
Saddle #11	23+90	*	*	*
Saddle #12	23+65	*	*	*
Saddle #13	23+40	*	*	*
Saddle #14	23+15	*	*	*
Saddle #15	22+90	*	*	*
Saddle #16	22+65	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #17	22+40	Water leak at top of tunnel. Slight coating damage & rusting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Between Saddle #18/ Support Rack	22+14 22+02.5	Water leak at top of tunnel. Slight coating damage & rusting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #19	21+90	*	*	*
Saddle #20	21+65	*	*	*
Saddle #21	21+40	*	*	*
Between Saddle #22/ Support Rack	21+15 21+02.5	Water leak at top of tunnel. Minor rust & coating damage observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #23	20+90	*	Water leak at top of tunnel. Minor coating damage.	*
Saddle #24	20+65	*	*	*
Saddle #25	20+40	*	*	*
Saddle #26	20+14	*	*	*
Saddle #27	19+90	*	*	*
Saddle #28	19+65	*	*	*
Saddle #29	19+40	*	*	*
Saddle #30	19+15	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #31	18+90	*	*	*
Saddle #32	18+65	*	*	*
Saddle #33	18+40	*	*	*
Saddle #34	18+14	Water leak at top of tunnel. Coating damage observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #35	17+90	*	*	*
Saddle #36	17+65	*	*	*
5' Concrete Anchor	17+50.2	Water leak at top of tunnel. Minor coating damage & rusting on west side.	*	*
Saddle #37	17+30	*	*	*
Between Saddle #38/ Support Rack	17+10.8 17+04.95	Water leak at top of tunnel. Minor coating damage & rusting on west side.	*	*
Saddle #39	16+90.1	*	*	*
Saddle #40	16+71.7	*	*	*
Saddle #41	16+56.2	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #42	27+39	Water leaks at top of tunnel. Coating damage & slight rusting	*	*
Saddle #43	27+22.7	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Saddle #44	26+97.8	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Concrete Anchor Bulkhead	26+78	Water leak at top of tunnel. Severe coating damage, severe rusting & major pitting measured at the bulkhead interface. This pitting is very serious (3/16") & should be repaired as soon as possible.	Severe water leak at top of tunnel. This pipe has a ½ circle welded repair patch at this location. There is severe rusting and pitting on the pipeline at the bulkhead interface. Pit depth was 3/16".	Severe water leak at top of tunnel. Water is leaking down bulkhead face. There is severe coating damage & heavy pitting at the bulkhead interface. Max. pit measured at 3/16".
Saddle #45	26+57.5	*	*	*
Saddle #46	26+17.5	*	*	*
Saddle #47	25+92.5	*	*	*
Saddle #48	25+67.5	Water leak at top of tunnel. Coating damage, slight rusting and pitting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #49	25+41	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
At Support Rack	25+30	Water leak at top of tunnel. Coating damage, slight rust & pitting observed.	Same condition as 16" Ø	*
Saddle #50	25+17.5	*	*	*
Saddle #51	24+92.5	*	*	*
Saddle #52	24+67.5	*	*	*
Between Saddle #53/ Support rack	24+42.5 24+30	Water leak at top of tunnel. Coating damage, rust & slight pitting observed.	Water leak at top of tunnel. Coating damage on bottom area of pipe.	*
Saddle #54	24+17.5	Water leak at top of tunnel. Coating damage.	*	*
Saddle #55	23+92.5	*	*	*
Saddle #56	23+67.5	*	*	*
Saddle #57	23+41	*	*	*
Between Saddle #58/ Support rack	23+17.5 23+05	*	Slight water leak at top of tunnel. Minor coating damage & rust.	*
Saddle #59	22+92.5	*	*	*
Saddle #60	22+67.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #61	22+42.5	*	*	Water leak at top of tunnel. Coating damage at top & side of pipe.
Saddle #62	22+17.5	*	*	*
Saddle #63	21+92.5	*	*	*
Saddle #64	21+67.5	*	*	*
Saddle #65	21+41	*	Water leak at top of tunnel. Coat- damage observed.	*
Saddle #66	21+17.5	*	*	Slight coating damage.
Saddle #67	20+92.5	*	*	*
Saddle #68	20+67.5	*	*	*
Saddle #69	20+42.5	*	*	*
Saddle #70	20+17.5	*	*	*
Saddle #71	19+92.5	*	*	*
5' Concrete Anchor	19+77.7	Water leak at top of tunnel. Coating damage, rusting & heavy pitting observed on west side of bulkhead at pipe/concrete interface. Pit depth measured at 1/16"	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #72	19+67.5	*	*	*
Saddle #73	19+41	*	*	*
Saddle #74	19+17.5	*	*	*
Between Saddle #75/ Saddle #90	18+92.5 15+17.5	*	*	*
Between Support rack/ Saddle #91	15+05 14+92.5	Water leak at top of tunnel. Coating damage, rust & slight pitting noted.	Same condition as 16" Ø	*
Saddle #92	14+67.5	*	*	*
Saddle #93	14+42.5	Water leak at top of tunnel. Rust & slight pitting noted on top & sides of pipe.	Same condition as 16" Ø	*
Saddle #94	14+17.5	*	*	*
Support rack	14+05	Water leak at top of tunnel. Rusting & slight pitting observed on side & bottom of pipe.	Same condition as 16" Ø	*
Saddle #95	13+92.5	*	*	*
Saddle #96	13+67.5	*	*	*
6" Concrete Bulkhead & Door	-------	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #97	13+41	*	*	*
Saddle #98	13+17.5	*	*	*
Saddle #99	12+92.5	*	*	*
5' Concrete Anchor	12+80.2	*	*	*
Saddle #100	12+49	*	*	*
Saddle #101	12+30.75 (122+80)	*	*	*
Saddle #102	122+61	*	*	*
Saddle #103	122+37	Water leak at top of tunnel. Moderate coating damage on pipe.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #104	122+13	*	*	Water leak at top of tunnel. Newly repaired coating is damaged & peeling off
Saddle #105	121+92.5	*	*	*
Saddle #106	121+51.1	*	*	*
5' Concrete Anchor	121+51.1	*	*	*
Saddle #107	121+37.5	*	*	*
Saddle #108	121+12.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #109	120+89	*	*	*
Saddle #110	120+62.4	*	*	*
6" Concrete Bulkhead		Water leak at top of tunnel. The pipe at this location recently had a leak repaired with a full circle weld patch. The concrete is broken out around it. The water leak, which caused the corrosion in the first place is continuing to wet the pipe surface. This leak is at the bulkhead interface.	*	*
Saddle #111	120+37.5	*	*	*
6" Concrete Bulkhead		*	*	*
Saddle #112	120+12.5	*	*	*
Saddle #113	119+87.5	*	*	*
Saddle #114	119+62.5	*	*	*
Saddle #115	119+37.5	*	*	*
Support Rack	119+25	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*
Saddle #116/ to Saddle #120	119+12.5/ 118+12.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #121	117+89.5	Water leak at top of the tunnel. Coating damage, rust & slight pitting observed.	*	*
Saddle #122/ Saddle #130	117+62.5/ 115+62.5	*	*	*
Support Rack	115+50	*	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.
Saddle #131	115+37.5	*	*	*
Support Rack	115+25	Water leak at top of tunnel. Coating damage, severe rust & slight pitting.	*	*
Saddle #132	115+12.5	*	*	*
Saddle #133	114+89	Severe water leak at top of tunnel. Heavy coating damage, rust and some pitting observed.	*	*
Saddle #134/ Saddle #137	114+62.5/ 113+87.5	*	*	*
Support Rack	113+75	Water leak at top of tunnel. Severe coating damage, rust & slight pitting observed.	*	*
Saddle #138	113+62.5	*	*	*
Saddle #139	113+32.5	*	*	*
Saddle #140	113+12.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Support Rack	113+00	Water leak at top of tunnel. Very severe coating damage, rust and pitting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #141	112+89	Very severe water leak at top of tunnel. The pipe at this location had an external corrosion leak approximately two years ago. The leak has been repaired with a bolted repair clamp & the pipeline has been re-coated. However, the repair clamp is still slightly leaking JP-5 fuel from its bottom.	*	Water leak at top of tunnel. Coating damage & rusting noted.
Saddle #142	112+62.5	*	*	*
Saddle #143	112+37.5	*	*	*
Saddle #144	112+12.5	*	Severe water leak at top & side of tunnel. Heavy coating damage, rusting & noticable pitting.	*
Saddle #145/ Saddle #148	111+87.5/ 111+12.5	*	*	*
Support Rack	110+98	Water leak at top of tunnel. Coating damage, rusting & slight pitting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #149	110+89	Water leak at top of tunnel. Coating damage, heavy rusting & slight pitting.	Same condition as 16" Ø	Same condition as 16" Ø

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
5' Concrete Anchor	110+69	Water leaks at top of tunnel. Coating damage and rusting at pipe-bulkhead interface.	*	*
Saddle #150/	110+55	*	*	*
Saddle #155	109+30	*	*	*
Saddle #156/ Saddle #238	109+05/ 88+21.5	The overall general condition of the pipeline between Station 109+05 and 88+21.5 is poor. There are numerous water leaks at the top and side of the tunnel. The magnitude of these leaks range from slow intermittent ones to constant high volume leaks. The majority of the coating is either visibly damaged or there is no effective bond between the undamaged coating and the pipe. Where the coating is damaged, there is moderate to severe rusting and numerous areas of corrosive attack. Also most of the galvanized sheet steel umbrellas over the pipeline are experiencing some form of corrosion damage.	Same condition as the 16" Ø	Same condition as the 16" Ø
Saddle #239	88+21.5	*	*	*
5' Concrete Anchor	87+94	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #240	87+72.5	*	*	*
Saddle #241/ Saddle #274	87+47.5/ 77+97.5	The overall general condition of the pipeline from Station 87+47.5 to 77+97.5 can be considered acceptable with no appreciable coating damage, rust or pitting. Also, the amount of water leakage from the top of the tunnel is almost nil at this time.	Same condition as 16" Ø	Same condition as 16" Ø
5' Concrete Anchor	77+90.3	*	*	*
Saddle #275/ Saddle #283	77+72.5 75+97.5	The overall general condition of the pipeline from Station 77+ 72.5 to 75.97.5 can be considered acceptable with no appreciable coating damage, rust or pitting. Also, the amount of water leakage from the top of the tunnel is almost nil at this time.	Same condition as 16" Ø	Same condition as 16" Ø
5' Concrete Anchor	75+86.5	*	*	*
Saddle #284	75+72.5	*	*	*
Saddle #285	75+47.5	*	*	*
Saddle #286	75+22.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #287/ Saddle #368	74+98/ 54+72.5	* The overall general condition of the pipe ftom Stations 74+98 to 54+72.5 can be considered acceptable, with very little coating damage or rust. The number and magnitude of the water leakage are also very minimal. It should be noted that there are internal steel H-Beam supports installed in this portion of the tunnel and that this extra internal bracing contributes to overall integrity of the tunnel surface thereby minimizing cracks and water leakage through the gunite.	* Same condition as 16" Ø	* Same condition as 16" Ø
Saddle #369	54+47.5	Water leak at top of tunnel. Coating damage, rusting and slight pitting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #370	54+22.5	*	*	*
Saddle #371	53+97.5	*	*	*
Saddle #372	53+72.5	*	*	*
Saddle #373	53+47.5	*	*	*
Saddle #374	53+22.5	Severe water leak at top of tunnel. Heavy coating damage, rust and some pitting noted.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #375/ Saddle #391	52+97.5 48+72.5	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #392	48+47.5	Water leak at top of tunnel. Coating damage and rust observed.	*	Same condition as 16" Ø
Support Rack	48+35	Water leak from top of tunnel. Coating damage and slight pitting	*	Water leak from top of tunnel. Heavy coating damage & rusting.
Saddle #393/ Saddle #405	48+22.5 45+22.5	*	*	*
Saddle #406	44+97.5	Water leak at top of tunnel. Coating damage & slight rusting noted.	*	*
Support Rack	44+85	Water leak at top of tunnel. Coating damage & rust noted.	Same condition as 16" Ø	*
Saddle #407	44+72.5	*	*	*
Saddle #408	44+47.5	*	*	*
Saddle #409	44+22.5	*	*	*
Saddle #410	43+97.5	Water leak at top and side of tunnel. Coating damage observed.	Same condition as 16" Ø	*
Saddle #411/ Saddle #428	43+72.5 39+56.5	*	*	*
5' Concrete Anchor	39+27	*	*	*
Saddle #429	39+12	Severe water leak at top of tunnel. Coating damage, rust & slight pitting.	Same condition as 16" Ø	*
Saddle #430/ Saddle #438	38+87/ 36+87	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #439	36+62	Heavy water leak at top of tunnel Coating damage, rust & slight pitting observed.	*	*
Support Rack	36+49.5	Heavy water leak at top of tunnel Coating damage, rust & slight pitting observed.	*	*
Saddle #440	36+37	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Support Rack	36+24.5	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Saddle #441	36+12	*	*	*
Saddle #442	35+87	*	*	*
Support Rack	35+74.5	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Saddle #443	35+62	Water leak at top of tunnel.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #444/	35+37	Severe water leak at top of tunnel. Heavy coating damage, rust and pitting noted.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #446/ Saddle #450	34+87 33+87	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Support Rack	33+74.5	Severe water leak at top of tunnel. Extensive coating damage rust and pitting observed.	Same condition as 16" Ø	*
Saddle #451/ Saddle #456	33+62/ 32+37	*	*	*
Support Rack	32+24.5	Heavy water leak at top of tunnel.Coating damage, rust & slight pitting.	Water leak at top of tunnel.	Same condition as 18" Ø
Saddle #457/ Saddle #466	32+12/ 29+87	*	*	*
Saddle #467	29+62	*	Water leak at top of tunnel. Severe coating damage, rust & slight pitting.	*
Saddle #468	29+37	*	*	*
Saddle #469	29+12	*	*	*
Saddle #470	28+87	Minor leak at top of tunnel. Coating damage & slight rust noted.	Same condition as 16" Ø	*
Saddle #471	28+62	*	*	*
Support Rack	28+49.5	Water leak at top of tunnel. Coating damage & slight rusting observed.	Same condition as 16" Ø.	*
Saddle #472	28+37	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #473	28+12	Water leak at top of tunnel. Coating damage, rust & slight pitting observed.	Same condition as 16" Ø	Water leak at top of tunnel. Coating damage & rust noted.
Saddle #474	27+87	Water leak at top of tunnel. Coating damage, rust & slight pitting observed.	Water leak at top of tunnel. Coating damage & rust noted.	*
Saddle #475	27+62	Water leak at top of tunnel. Coating damage & slight rust noted.	Same condition as 16" Ø	*
Saddle #476	27+37	*	*	Water leak at top of tunnel. Coating damage & slight rust noted.
Saddle #477	27+12	Water leak at top of tunnel. Coating damage, rust & slight pitting.	Same condition as 16" Ø	*
Saddle #478/ Saddle #480	26+87/ 26+37	*	*	*
Support Rack	26+24.5	*	Water leak at top of tunnel. Heavy coating damage, rust & slight pitting.	*
Saddle #481	26+12	*	*	*
Saddle #482	25+87	*	*	*
Support Rack	25+74.5	Water leak at top of tunnel. Coating damage & rust.	Same condition as 16" Ø	Same condition as 16" Ø

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #483/ Saddle #485	25+62/ 25+12	*	*	*
Support Rack	24+99.5	Water leak at top of tunnel. Minor coating damage & rust observed.	*	*
Saddle #486	24+87	*	*	*
Saddle #487	24+62	*	*	*
Saddle #488	24+37	*	Water leak at top & side of tunnel. Severe coating damage & rusting noted.	*
Saddle #489	24+12	*	*	*
Saddle #490	23+87	*	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.
Saddle #491 Saddle #492	23+62/ 23+51.5	Heavy water leak at top of tunnel. Severe coating damage, rust * slight pitting.	Same condition as 16" Ø	*
Support Rack	23+24.5	*	*	Water leak at top of tunnel Coating damage & slight rusting on back side of pipe.
Saddle #493	23+12	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
5' Concrete Anchor/ Saddle #495	22+99.2/ 22+51	Heavy water leak at top of tunnel. Severe coating damage, rust and moderate pitting.	Same condition as 16" Ø	*
Support Rack	22+38	Severe water leak at top of tunnel. Heavy coating damage rust and slight pitting.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #496/ Saddle #502	22+26 20+93	*	Minor water leak at top of tunnel Coating damage & slight rusting observed.	*
5' Concrete Anchor/ Saddle #506	20+79.7/ 19+92	*	Minor water leak at top of tunnel. Coating damage observed & slight rusting noted.	*
Saddle #507	19+67	Water leak at top of tunnel. Coating damage & minor rusting noted.	Same condition as 16" Ø	Water leak at top of tunnel. Coating damage, rust & slight pitting.
Saddle #508	19+42	*	*	*
Saddle #509	19+17	*	*	*
Support Rack	19+04.5	Water leak at top of tunnel. Coating damage & rusting observed.	Same condition as 16" Ø	Same condition as 16" Ø
Saddle #510	18+92	Water leak at top of tunnel. Coating damage & rust observed.	Water leak at top of tunnel. Severe coating damage & heavy rusting.	Same condition as 18" Ø
Saddle #511	18+67	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #512	18+42	*	Severe water leak at top of tunnel. Heavy coating damage & severe rusting noted.	Same condition as 18" Ø
Support Rack	18+29.5	*	Water leak at top of tunnel. Coating damage & rusting noted.	Same condition as 18" Ø
Saddle #513/ Saddle #517	18+17 17+17	*	*	*
Saddle #518/ Saddle #519	16+92 16+67	Water leak at top of tunnel. Coating damage & major rusting noted.	Same condition as 16" Ø	*
Saddle #520/ Saddle #523	16+42 16+17	*	*	*
Support Rack	16+04.5	*	Severe water leak at top of tunnel. Heavy coating damage & severe rust observed.	Same condition as 18" Ø
Saddle #524/ Saddle #527	15+92/ 15+17	*	*	*
5' Concrete Anchor	15+00	*	*	*
Saddle #528	14+88.5	Water leak at top of tunnel. Coating damage, rust & slight pitting.	Same condition as 16" Ø	*
Saddle #529	14+64	*	*	*

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #530	14+39.5	*	Water leak at top of tunnel. Coating damage & rusting.	*
Saddle #531	14+15	*	*	*
Support Rack	14+02.5	Water leak at top of tunnel. Coating damage & rusting noted.	*	*
Saddle #532	13+91.5	*	*	*
Saddle #533	13+66	Water leak at top of tunnel. Coating damage & rusting observed.	*	*
Saddle #534/ Saddle #538	13+41/ 12+16	*	Water leak at top of tunnel. Heavy coating damage, rust & slight pitting.	*
Saddle #539	11+94.5	*	*	*
Saddle #540	11+70	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Saddle #541	11+45.5	*	Water leak at top of tunnel. Coating damage, rust & slight pitting	*
Saddle #542	11+21	*	*	*
Support Rack	11+08.5	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.	Same condition as 18" Ø

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #543	10+96.5	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*
Support Rack	10+84	*	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*
Saddle #544	10+72	*	*	*
Support Rack	10+59.5	Water leak at top of tunnel. Coating damage, heavy rust & slight pitting.	Water leak at top of tunnel. Coating damage & rust.	*
Saddle #545	10+47.5	*	*	Water leak at top of tunnel. Severe coating damage, rust & slight pitting.
Saddle #546	10+23	*	*	*
Saddle #547	9+98.5	Water leak at top of tunnel. Coating damage & rust noted.	Heavy water leak at top of tunnel. Severe coating damage, rust & slight pitting.	*
Support Rack	9+61.5	Water leak at top of tunnel. Coating damage, rust & slight pitting.	*	*
Saddle #549/ Saddle #552	9+48 8+76	*	*	*
Saddle #554/ Saddle #599		THESE SADDLES NUMBERS DO NOT EXIST.		

TABLE NO. XXIII-C

LOCATION	STATION NO.	16" Ø	18" Ø	32" Ø
Saddle #600/ Saddle #638		*	*	*

*Note: Where no comment is made as to the condition of the pipeline, no visible damage was apparent. However, since the coating may be disbonded at any of these locations, one should not assume the condition of the pipeline is acceptable with respect to corrosion damage.

R&P Laboratory, Inc
1452 W GAYLORD ST., LONG BEACH, CALIF 90813

We make water work

TABLE NO. XXIII-D

REPORT OF WATER ANALYSIS

PACIFIC CORROSION RESEARCH

DATE: June 1, 1982

Tunnel Water

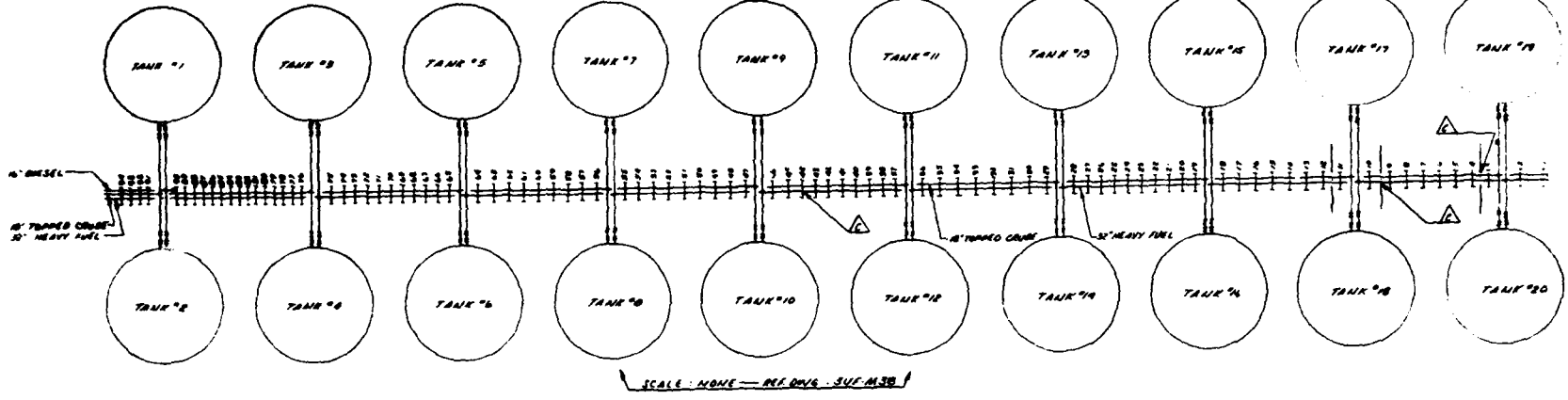
DATE OF SAMPLE: _____

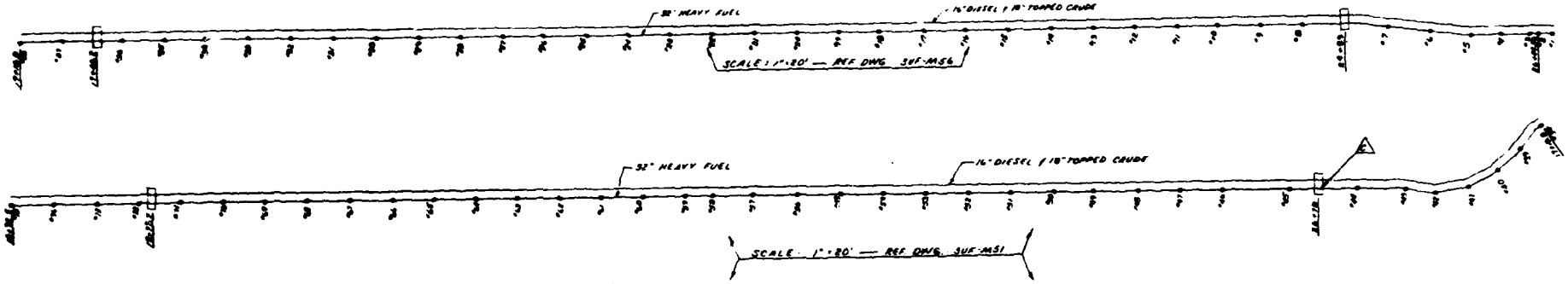
SAMPLE SOURCE	Tank 16						
TOTAL HARDNESS ($CaCO_3$) ppm	96						
CALCIUM ($CaCO_3$) ppm	72						
MAGNESIUM ($CaCO_3$) ppm	24						
P. ALKALINITY ($CaCO_3$) ppm							
T. ALKALINITY ($CaCO_3$) ppm	140						
CHLORIDE (Cl) ppm	36						
pH	7.3						
TOTAL PHOSPHATE (PO_4) ppm	0.4						
ORTHO PHOSPHATE (PO_4) ppm	0.4						
SULFITE (SO_3) ppm	-						
CHROMATE (CrO_4) ppm	-						
NITRITE ($NaNO_2$) ppm	-						
CONDUCTIVITY (mmhos)	200						
IRON, (Fe) ppm	nil						
COPPER (Cu) ppm	0.3						
SULFATE (so4) ppm	64						

COMMENTS: Resistivity 5,000 ohm cm

This water would not be considered highly corrosive by itself. However, in an aerated environment it would result in severe corrosion of iron pipe. To protect the pipe in this environment, the parts should be coated with an impervious material such as an epoxy or similar type coating.

CERTIFIED: _____





LEGEND

- CONCRETE ANCHOR
- CONCRETE SADDLE / NUMBER
- H-BEAM SUPPORT / NUMBER
- REVISE CORROSION DAMAGE (REFER TABLES FOR DETAILED DESCRIPTION)

NOTE

1. SADDLE NUMBERS "559 THRU "579 DO NOT EXIST PRIOR TO AND FOLLOWS SADDLE "558 WITH NO EXISTING CONCRETE SADDLES BETWEEN THEM.

REVISIONS				
NO	DESCRIPTION		DATE	APPROVED

PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
9681 B CORBETT VIL DRIVE
HUNTINGTON BEACH CALIFORNIA
DRAWN RLS DATE 6-21-88
APPROVED
PCR DWG NO 6537

GRAPHIC SCALES IN FEET
0 10 20 40 60
1" = 20'

IF SHEET IS LESS THAN 22" X 17" IT IS A REDUCED PRINT — SCALE SHOWN ACCORDINGLY

PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND

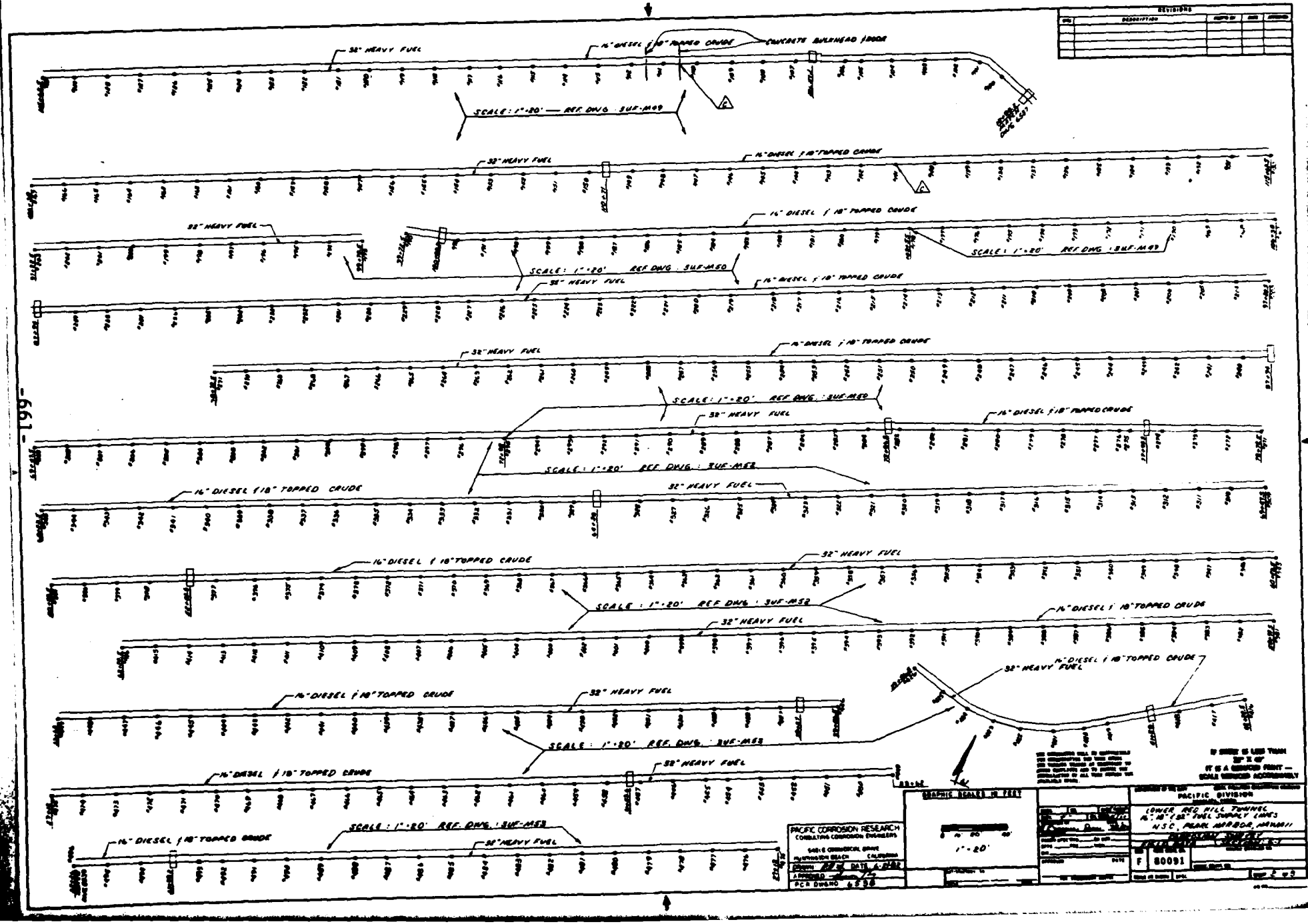
LOWER REED HILL TUNNEL
16", 18", & 32" FUEL SUPPLY LINES
NSC, PEARL HARBOR, HAWAII

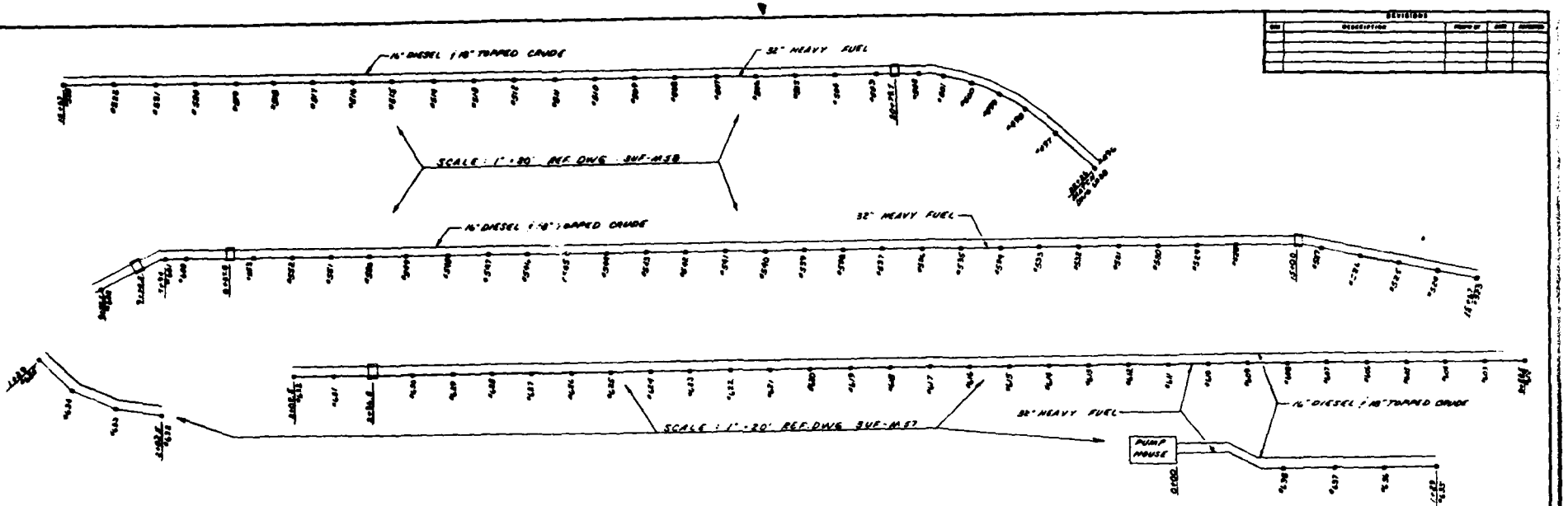
CORROSION SURVEY
AS-BUILT

F 80093

SHEET 1 OF 5

-660-


32" HEAVY FUEL
16" DIESEL / 18" TOPPED CRUDE
CONCRETE BULKHEAD (BOOM)
SCALE: 1"=20' — REF DWG SUF-M49
SCALE: 1"=20' REF DWG: SUF-M49
SCALE: 1"=20' REF DWG: SUF-M50
SCALE: 1"=20' REF DWG: SUF-M51
SCALE: 1"=20' REF DWG: SUF-M52
SCALE: 1"=20' REF DWG: SUF-M53
SCALE: 1"=20' REF DWG: SUF-M54
REVISIONS
GRAPHIC SCALES IN FEET
1"=20'
PACIFIC CORROSION RESEARCH
CONSULTING CORROSION ENGINEERS
PACIFIC DIVISION
LOWER AREA FUEL TANKAGE
16", 18" & 32" FUEL SUPPLY LINES
N.S.C., PEARL HARBOR, HAWAII
F 80091


16" DIESEL / 18" TOPPED CRUDE
32" HEAVY FUEL
SCALE : 1" = 20' REF DWG SUF-M38
16" DIESEL / 18" TOPPED CRUDE
32" HEAVY FUEL
SCALE : 1" = 20' REF DWG SUF-M37
32" HEAVY FUEL
16" DIESEL / 18" TOPPED CRUDE
PUMP HOUSE

APPENDIX

APPENDIX

SAMPLE SPECIFICATIONS X-TRU-COATED STEEL PIPE

DRAWINGS FIELD DATA DRAWINGS

COLOR CODED DRAWINGS

SAMPLE SPECIFICATION

POLYETHYLENE PLASTIC COATED STEEL PIPE

This specification sets forth the minimum requirements for a polyethylene plastic coated pipe.

It describes the adhesive undercoating applied to the exterior surface of the pipe; the plastic sheath applied over the adhesive; and the final coated pipe product.

1. Adhesive Undercoating

The adhesive shall consist of a blend of a rubber, asphalt and high molecular weight resins. It shall be permanently tacky and adhere to both the steel pipe and the plastic sheath. The adhesive undercoating shall have the properties as specified for X-Tru-Coat or equal.

2. Polyethylene Plastic Sheath

The resin shall be prime virgin, high density polyethylene copolymer.

The properties of the plastic sheath materials shall be as follows:

PROPERTIES OF POLYETHYLENE

Property	Test Method	Requirement
Density (pigmented), D^{23D}, g/cm^3	ASTM D1505	Min. 0.957*
Flow Rate, g/10min	ASTM D1238	Max. 0.75
Yellow Pigment Content,% by wt.		Min. 2.0

3. Coated Pipe System

The exterior surface of the pipe to be coated shall be abrasive steel shot or grit blast cleaned to Steel Structures Painting Council Surface Preparation No. Six Commercial Blast Cleaned, SSPC-SP-6. The exterior pipe surface shall also be dry. The adhesive undercoating shall

be applied with a minimum thickness of 8 mil at 285° - 310° F.

The plastic sheath shall be extruded over the adhesive undercoating to provide a smooth sheath that is free of pinholes, bubbles, blisters, wrinkles, cracks or mechanical voids. The thickness of the plastic sheath applied to various pipe sizes shall be as follows:

THICKNESS OF POLYETHYLENE PLASTIC SHEATH

Pipe Size, Inches	Standard Sheath Thickness, mils	
	Nominal	Minimum
½ to 2, nominal	25	23
2-7/8, OD	30	27
3½. 4, 4-12, OD	35	32
5-9/16, OD	40	36
over 6-5/8, OD	40	36

The ends of the pipe shall be uncoated and the cut-back shall extend to approximately 4 inches from each end of plain-end pipe and approximately 2 inches from the last thread on threaded pipe.

4. Field Joints on Pipe and Fittings

The field joints shall consist of cleaning by wire brusing or grit blasting prime, wrap 6" beyond polyethylene coating in either direction with 2"x45 mil butyl rubber tape, half lapped to a minimum thickness of 60 mils. The entire joint or fitting shall be half lapped with 10 or 12 mil pressure sensitive polyethylene or PVC plastic tape.

5. Inspection

The coated pipe shall be electrically tested for defects using a holiday detector operating at 8,000 v. minimum. Any failures in the coating or field joints shall be repaired as specified for field joints.

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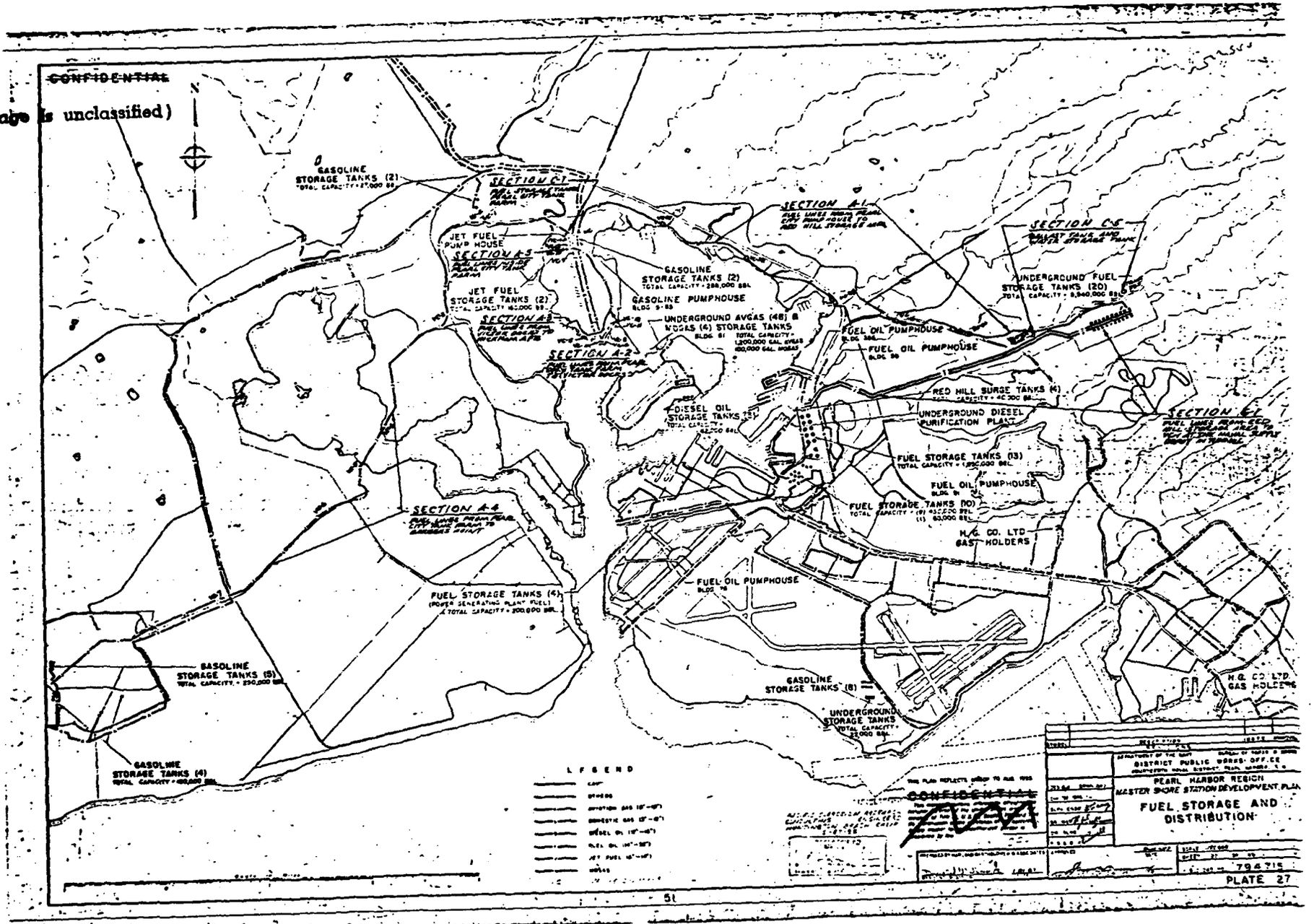

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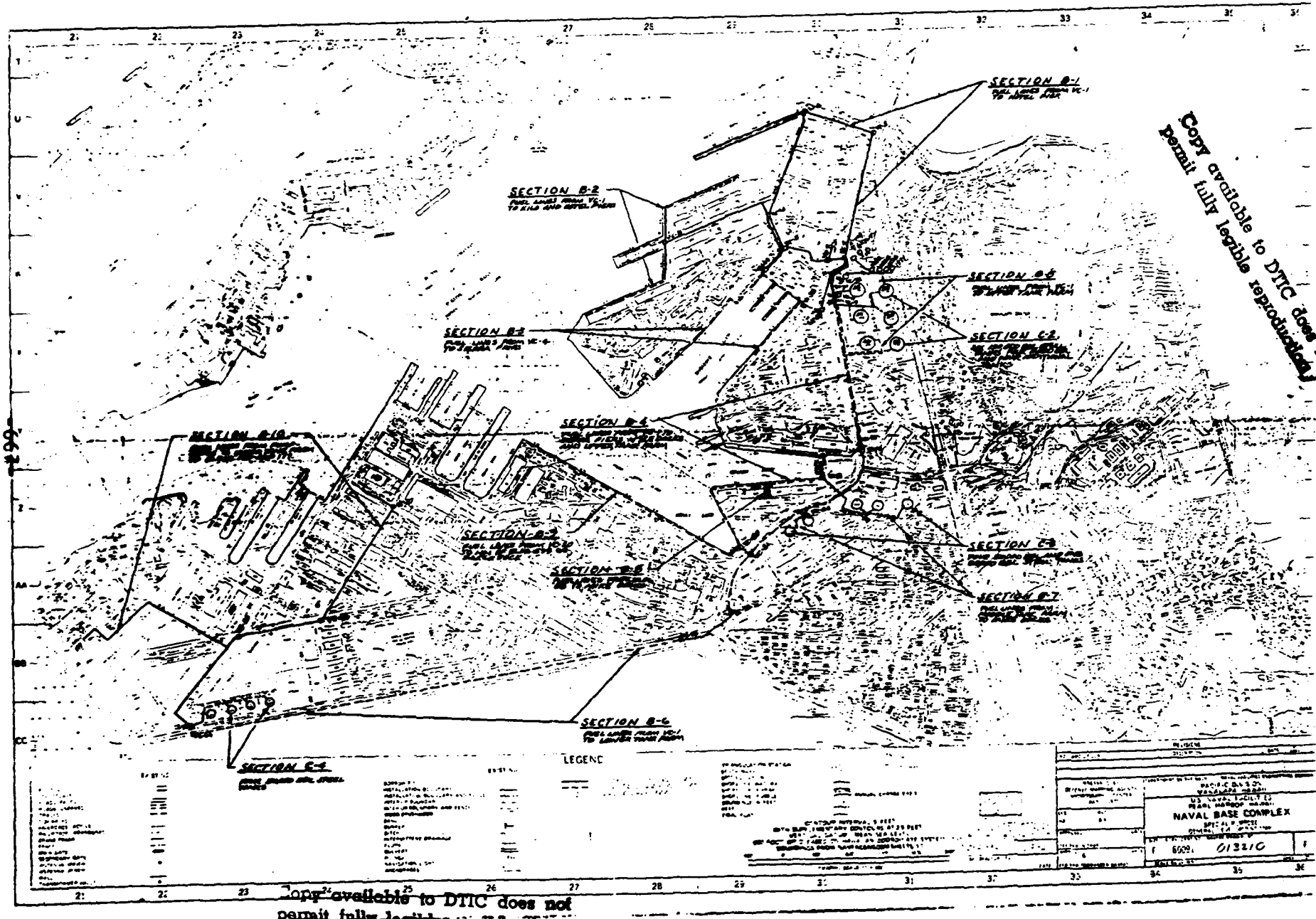

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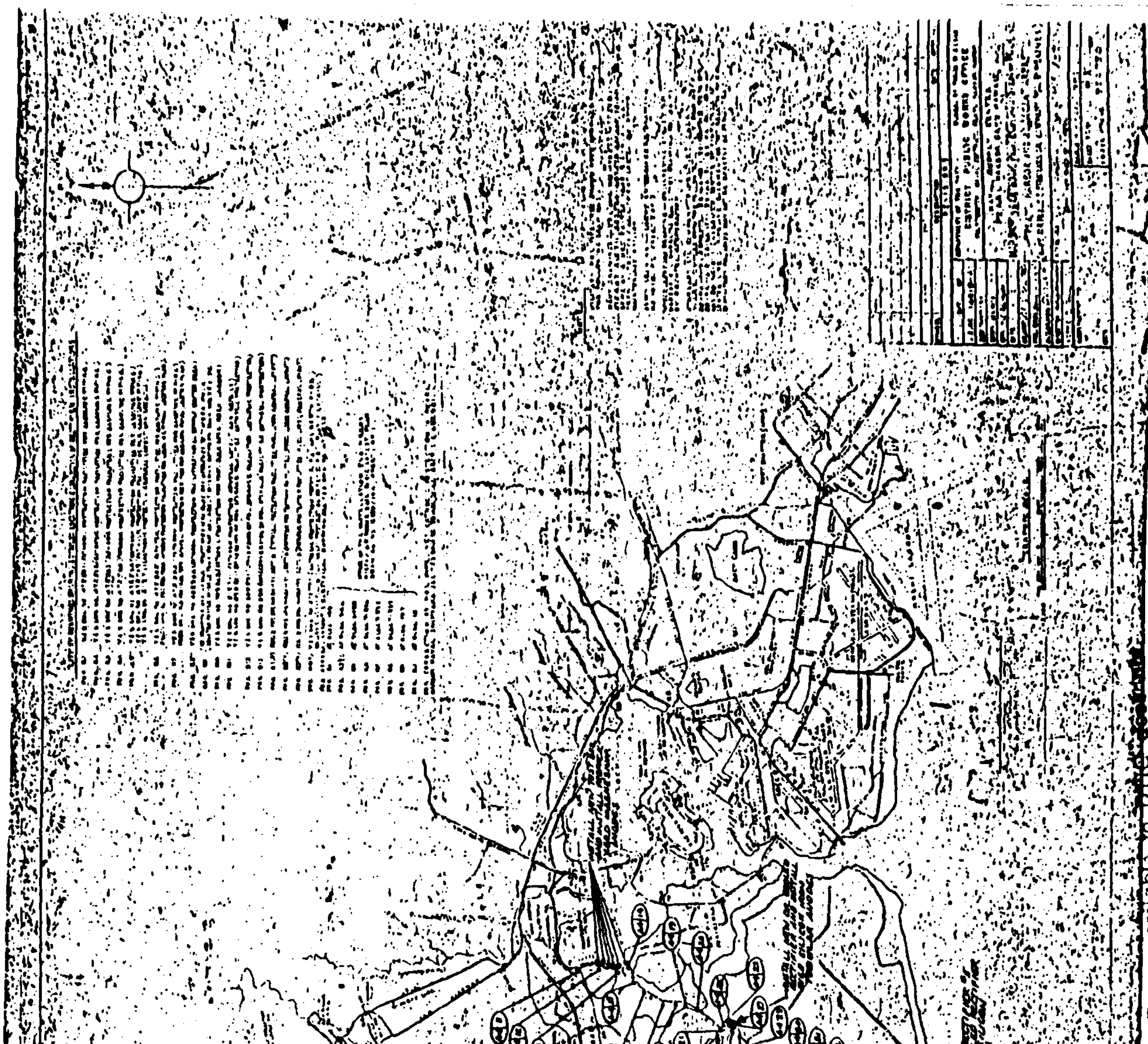

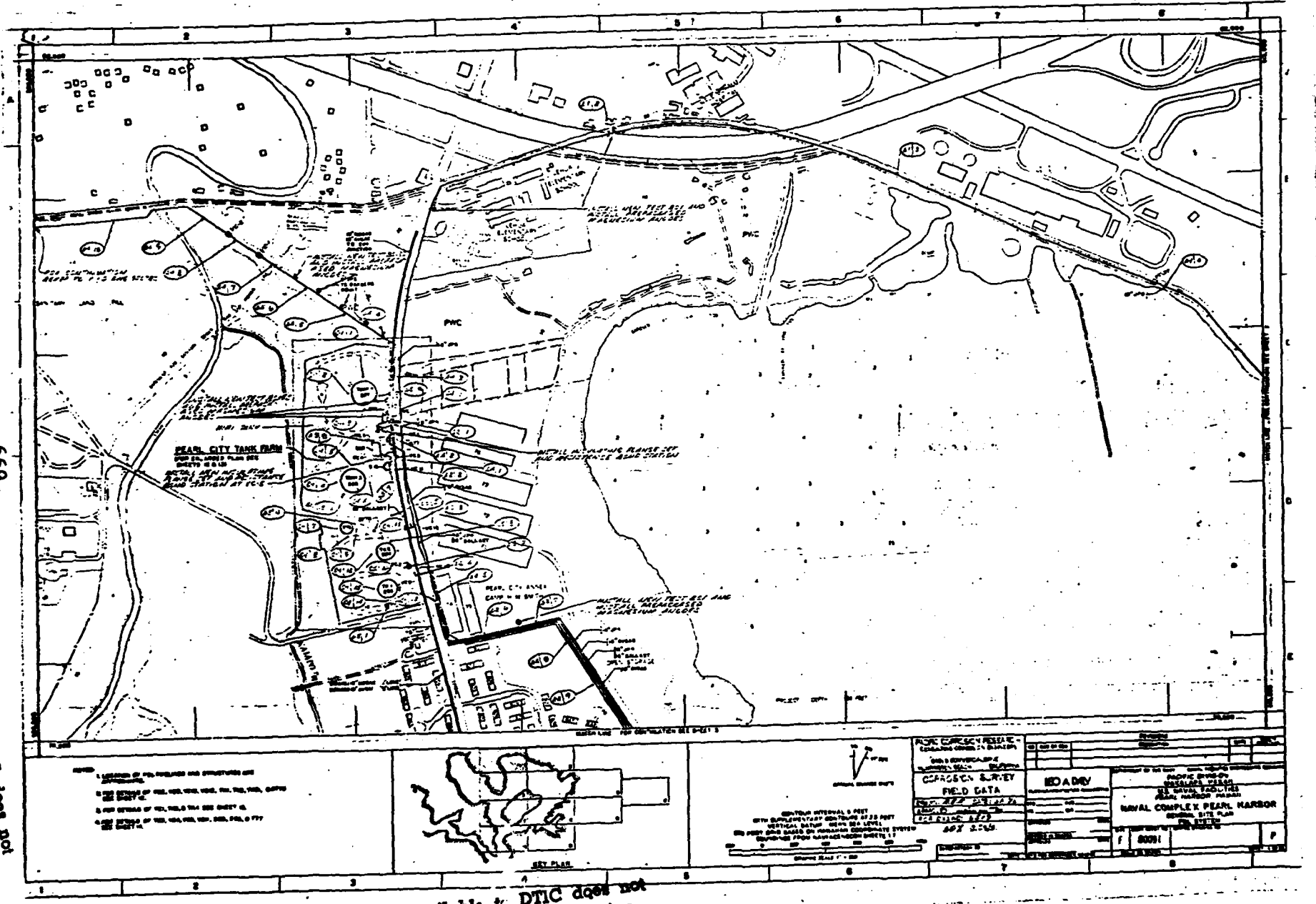

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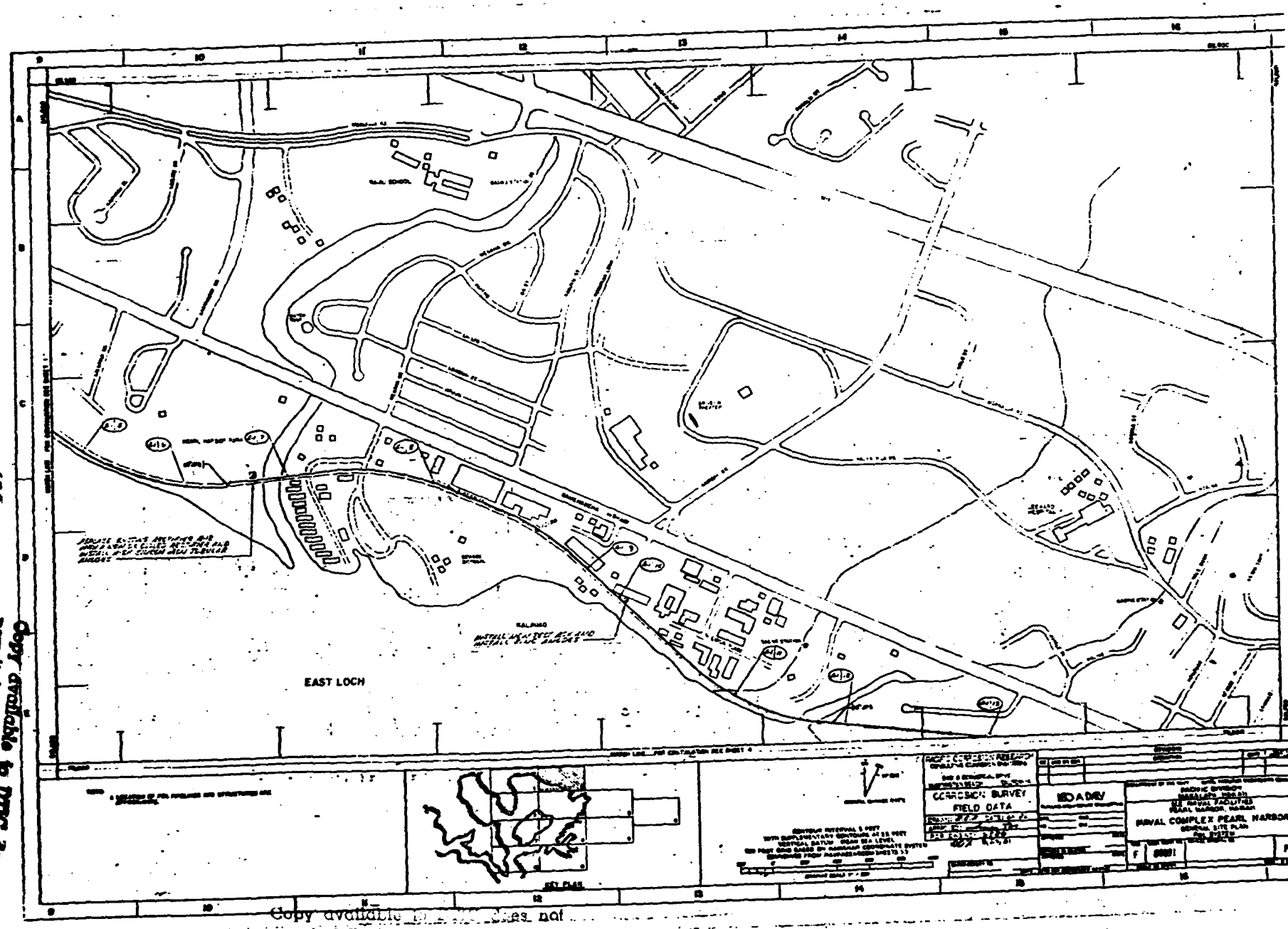

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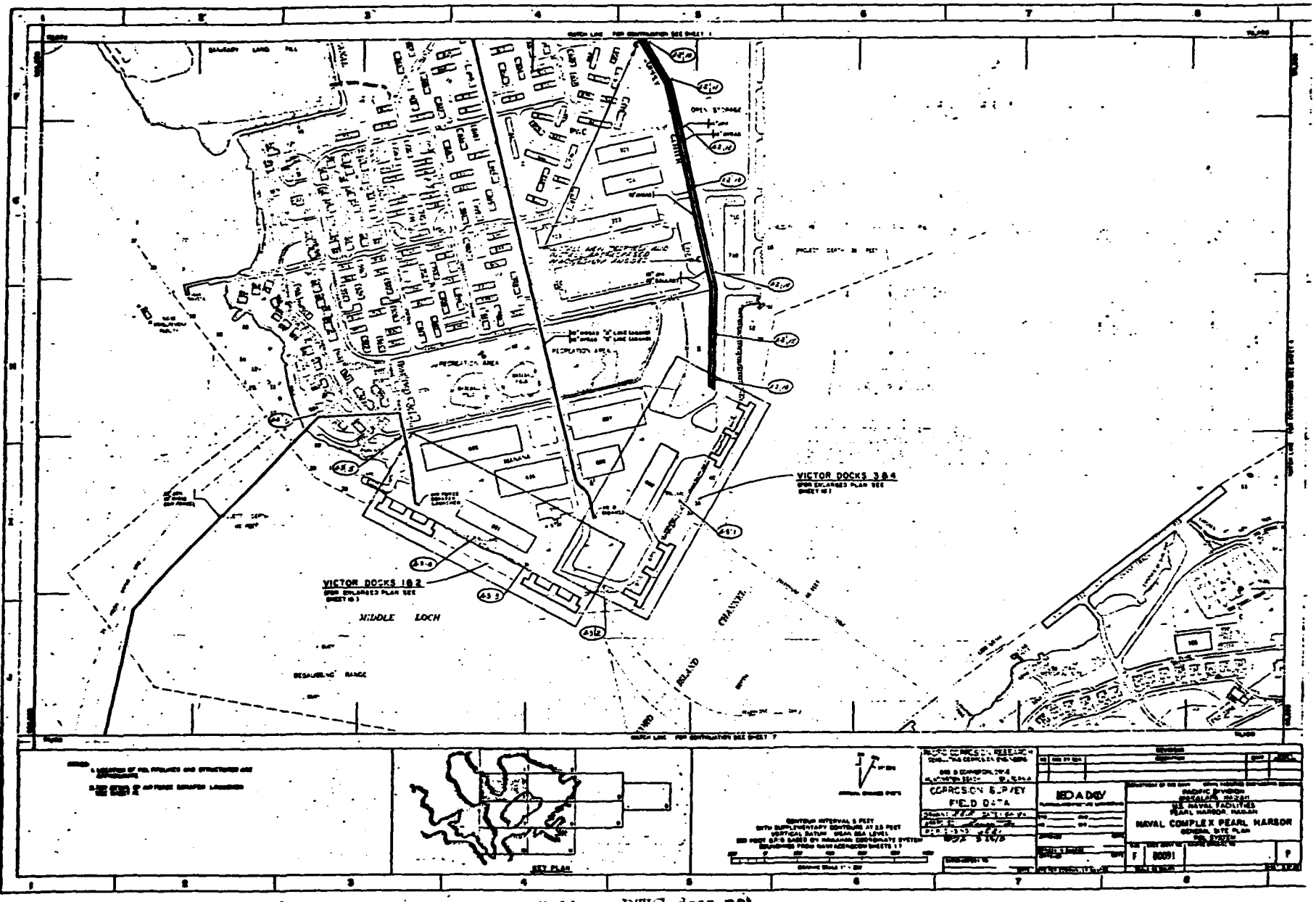

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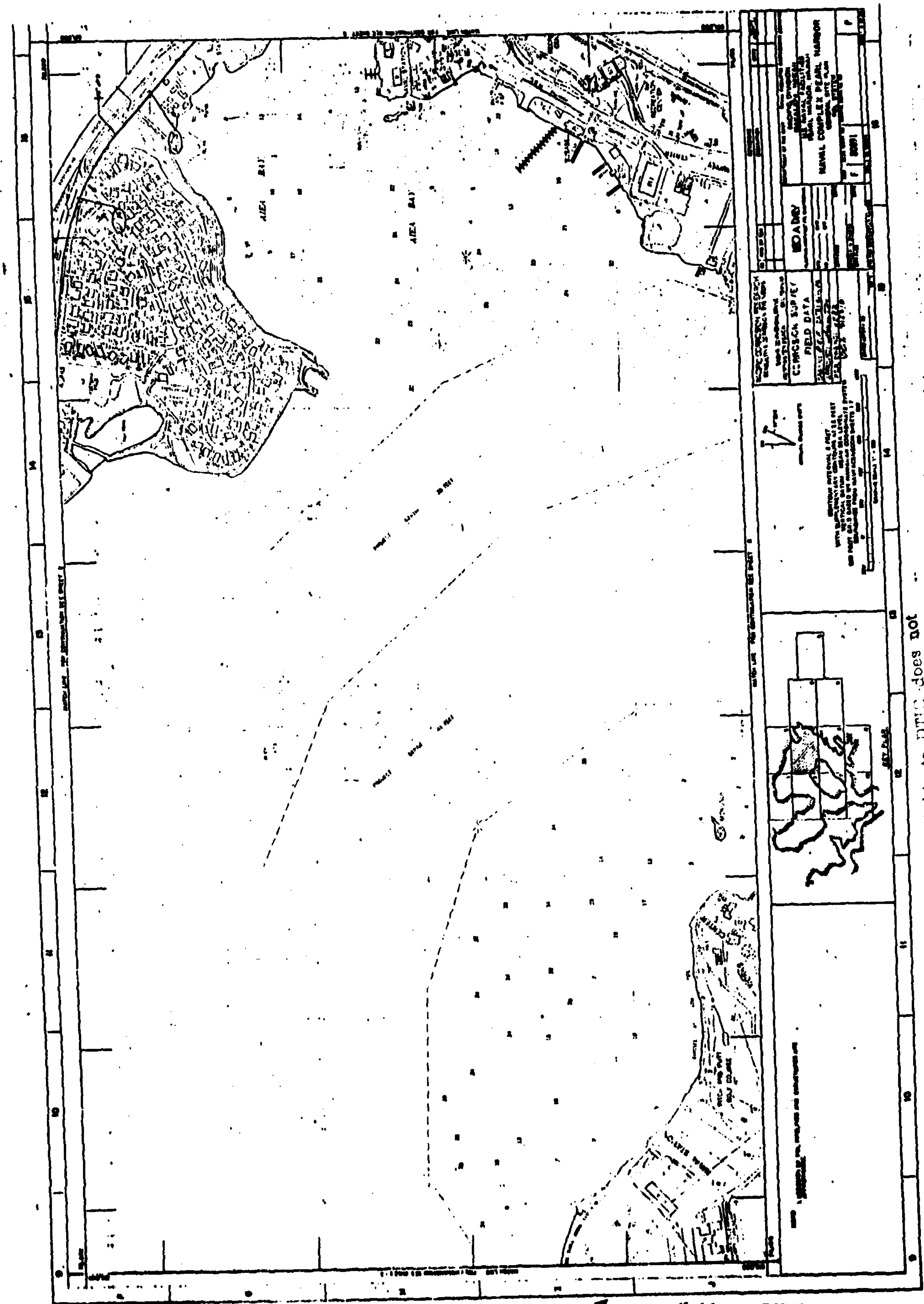

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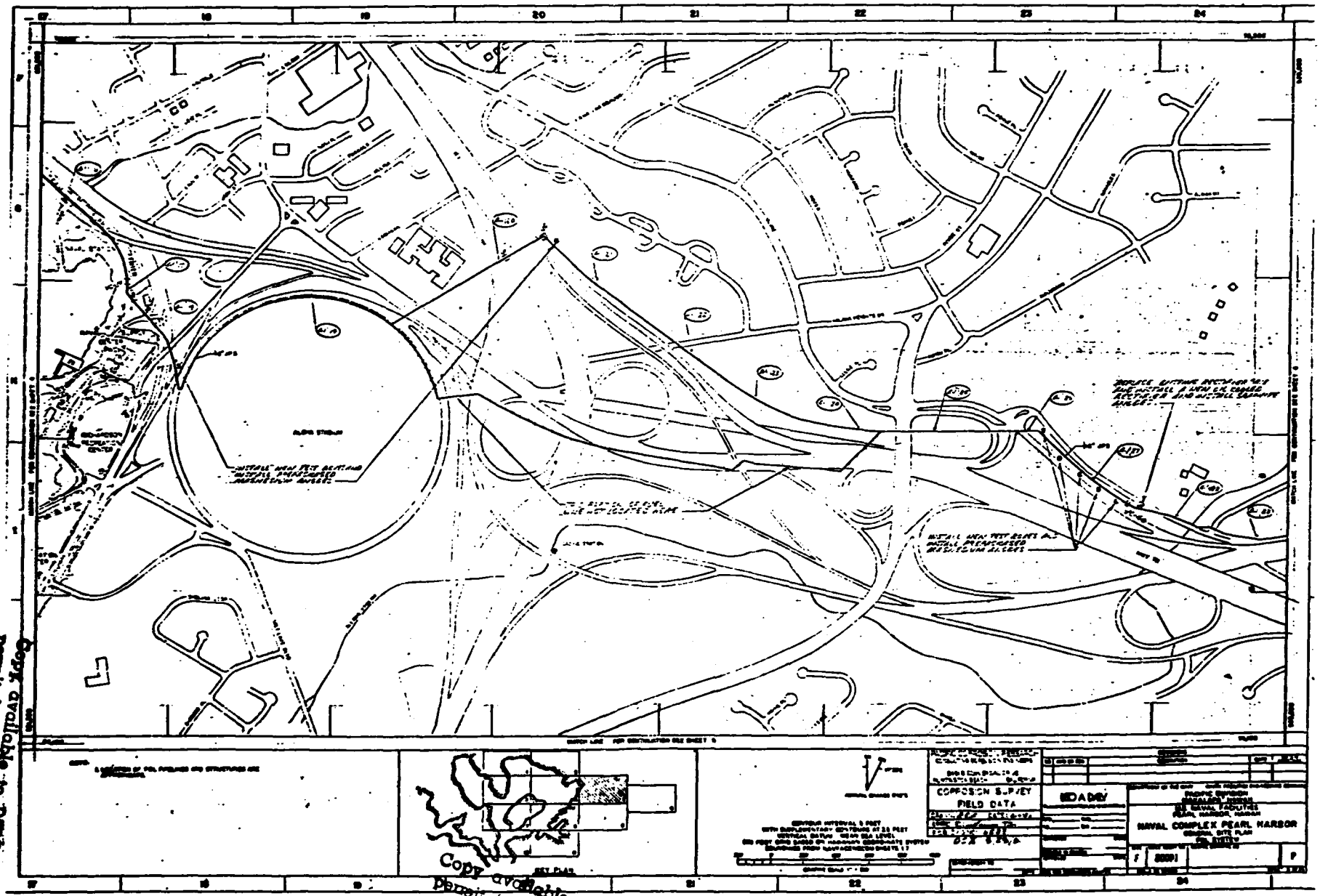

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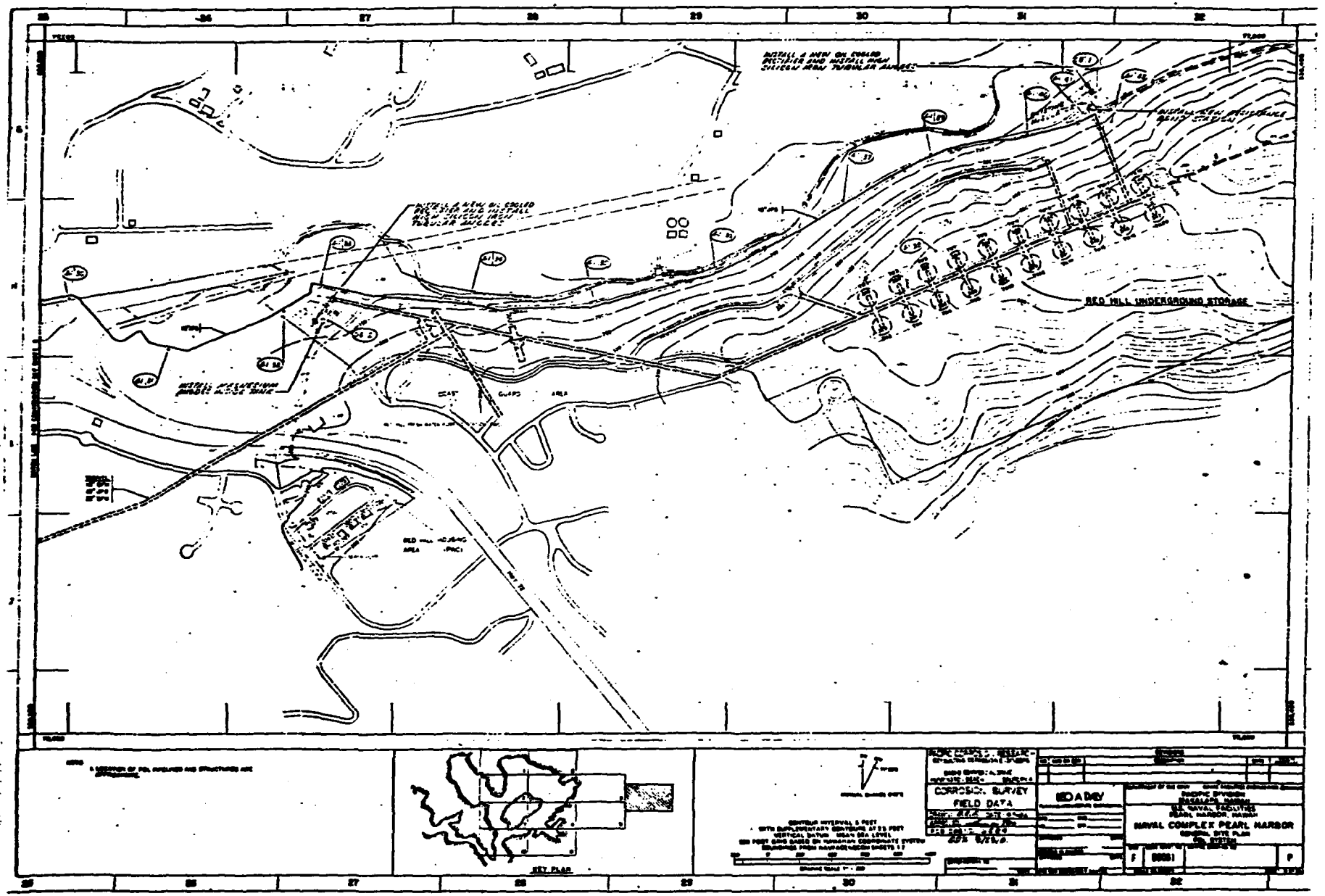

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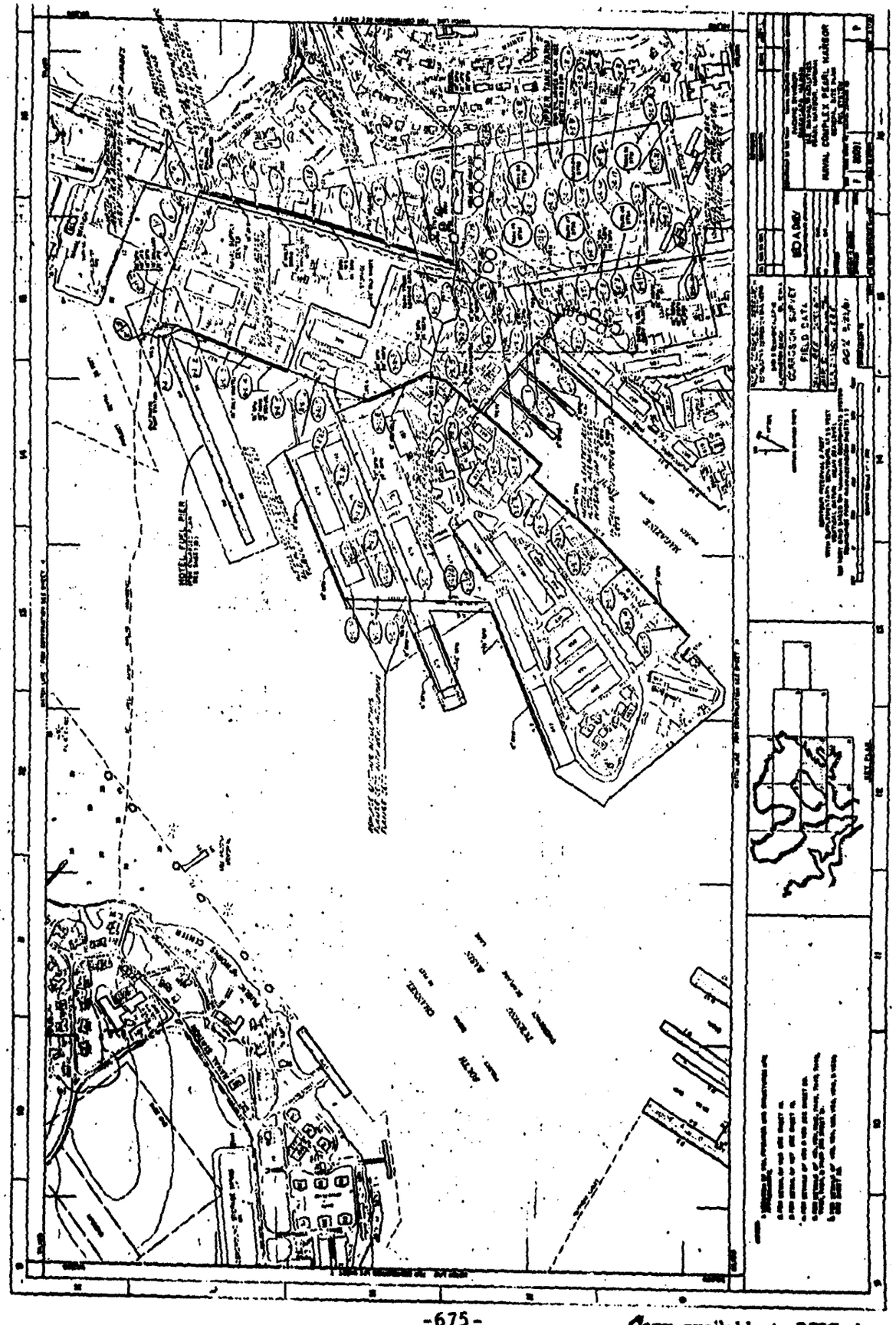

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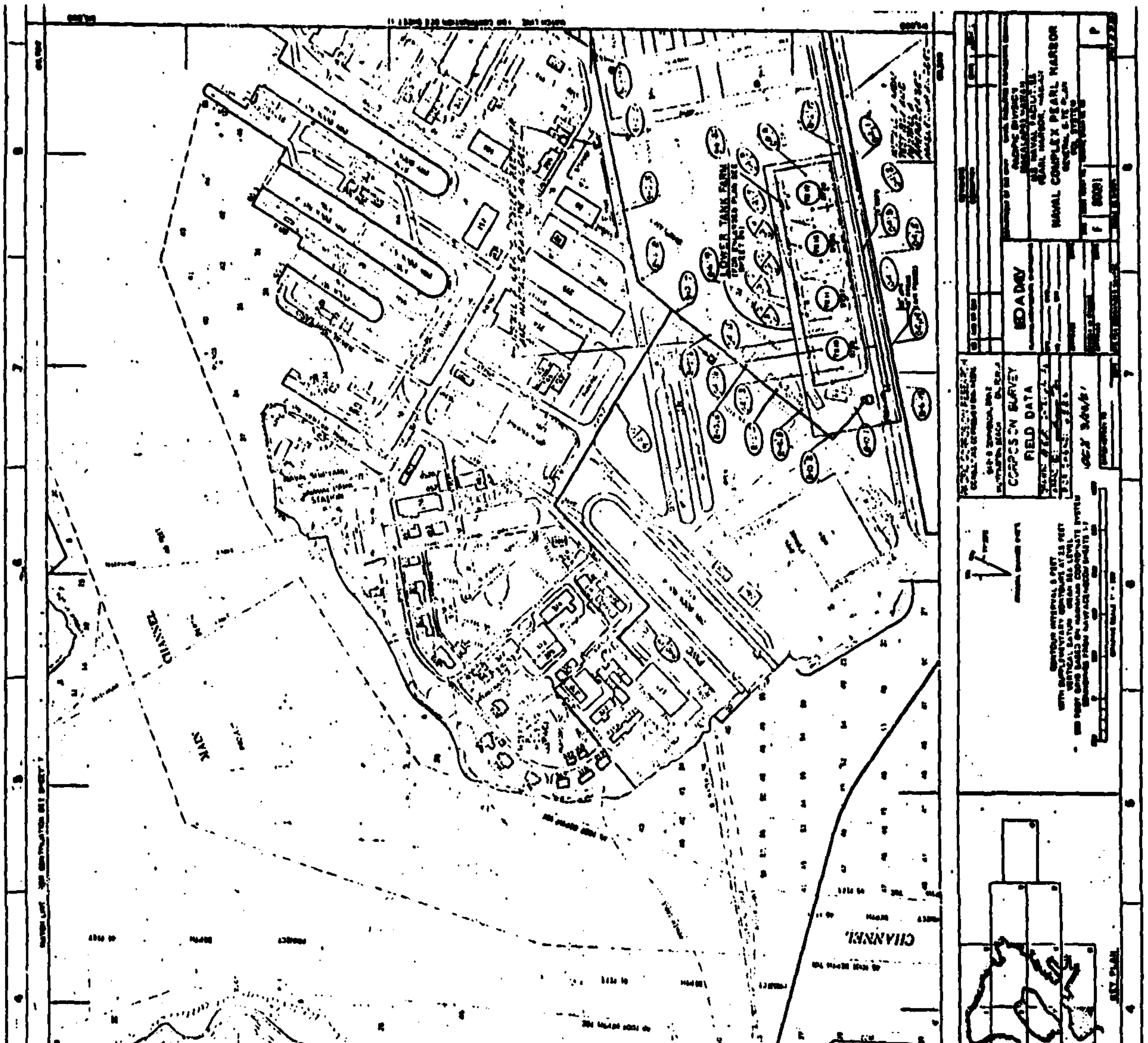

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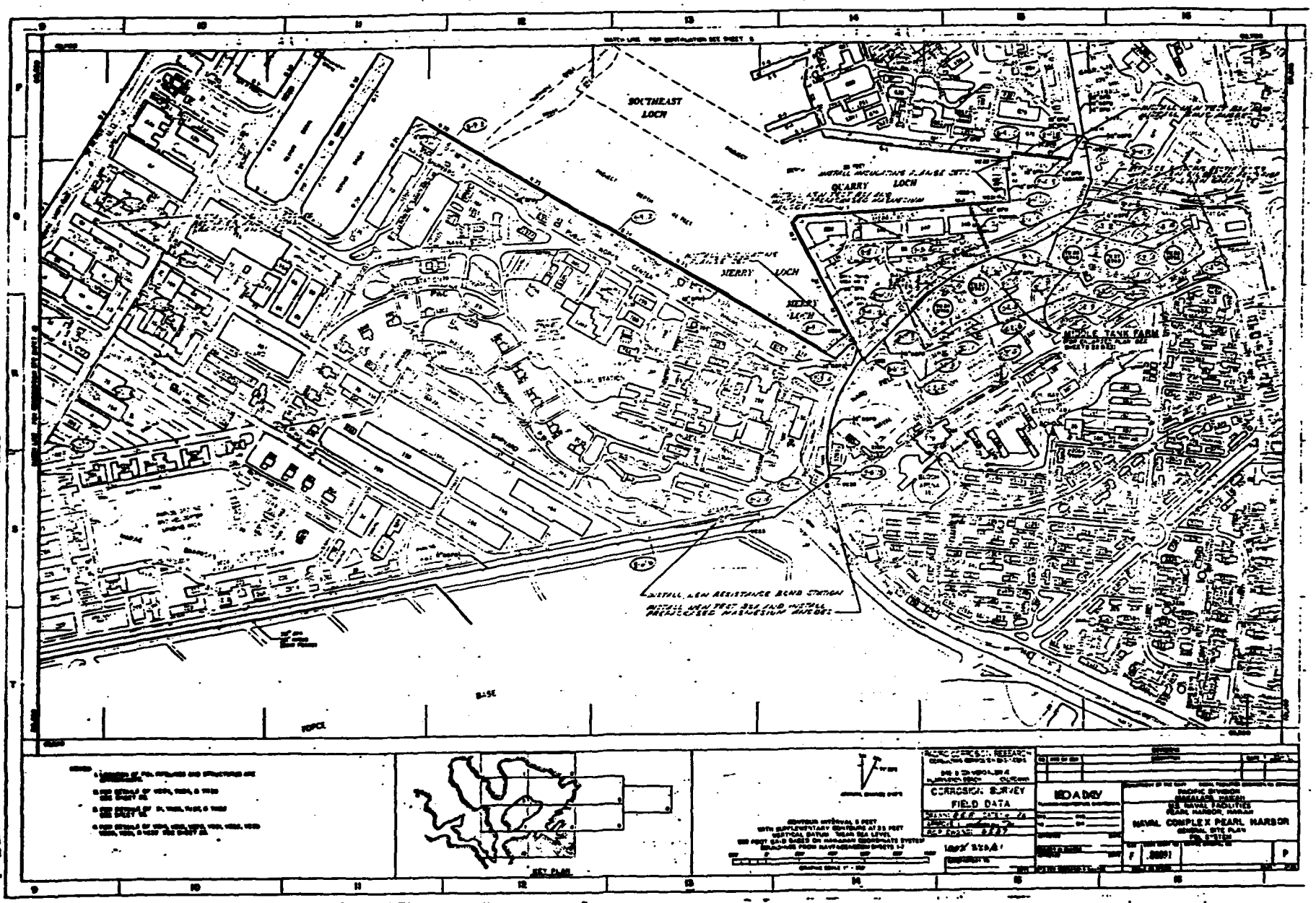

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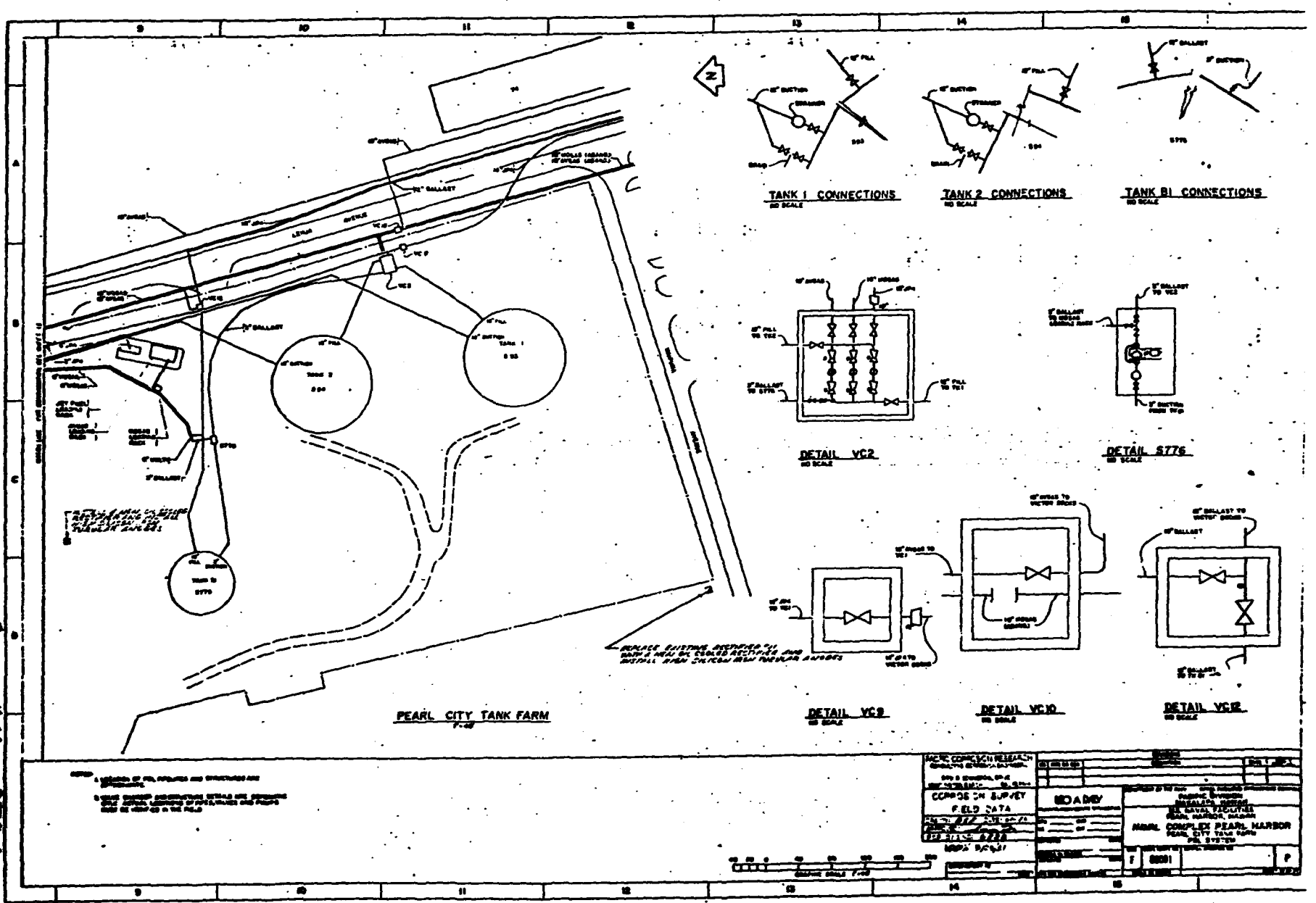

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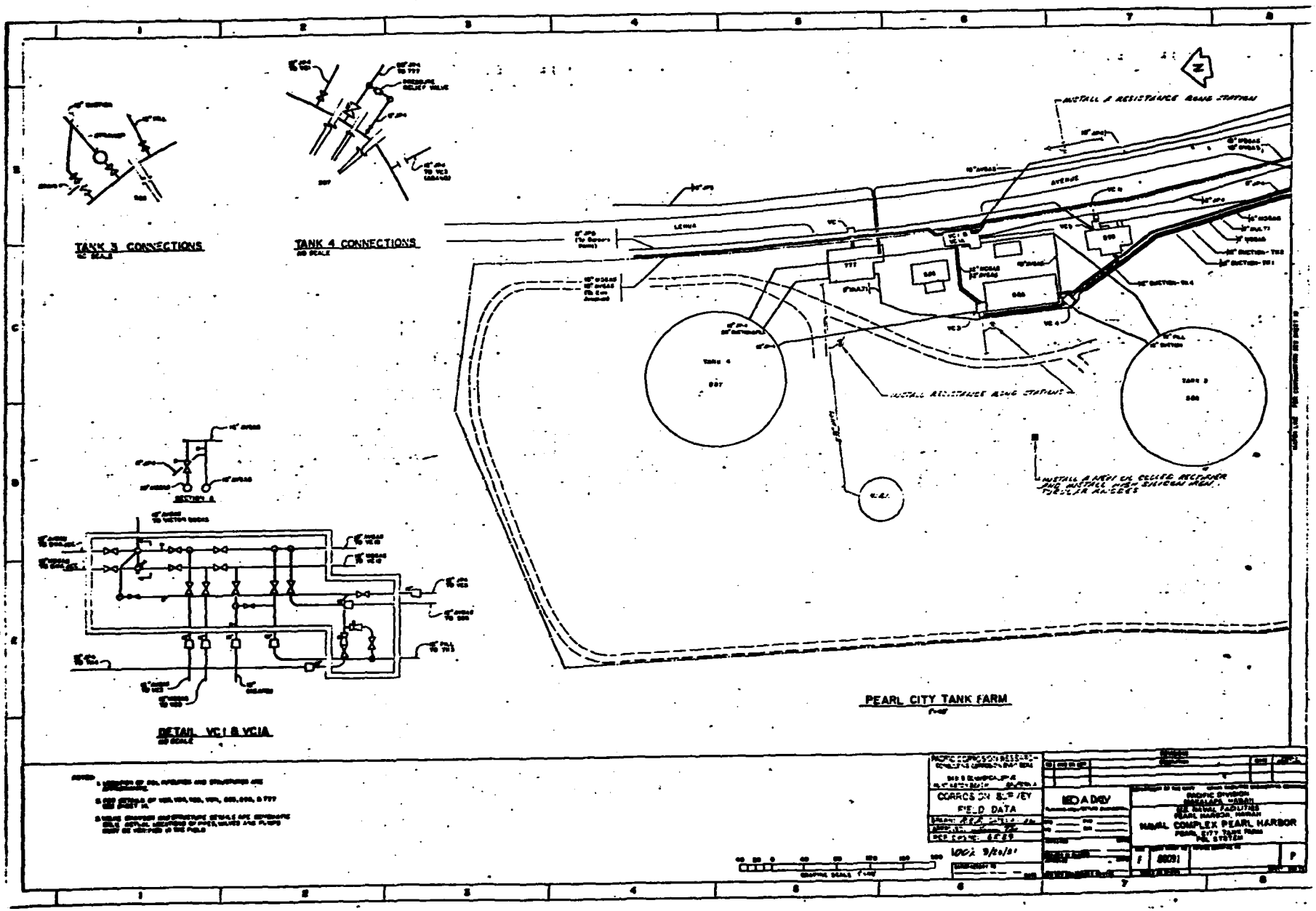

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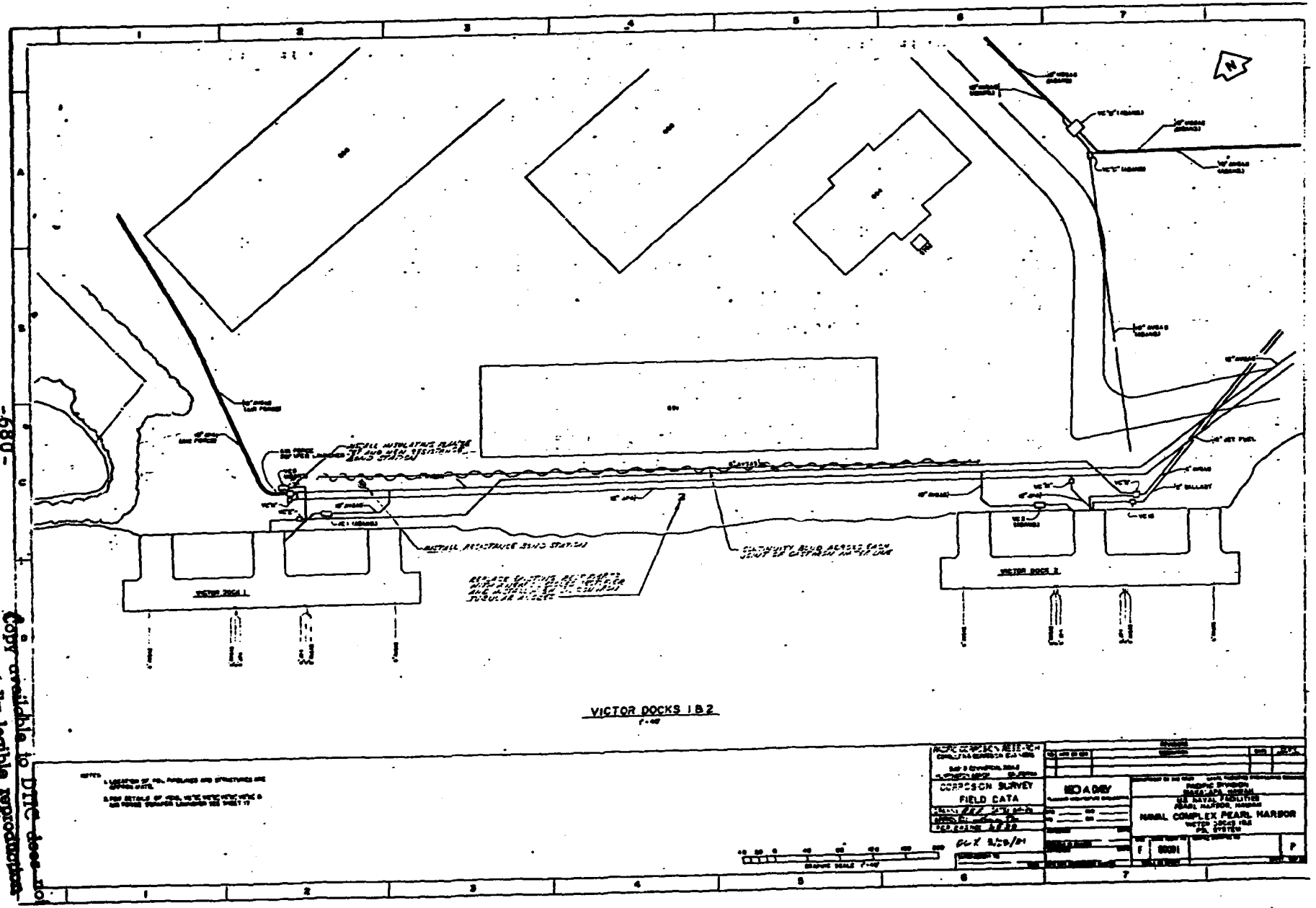

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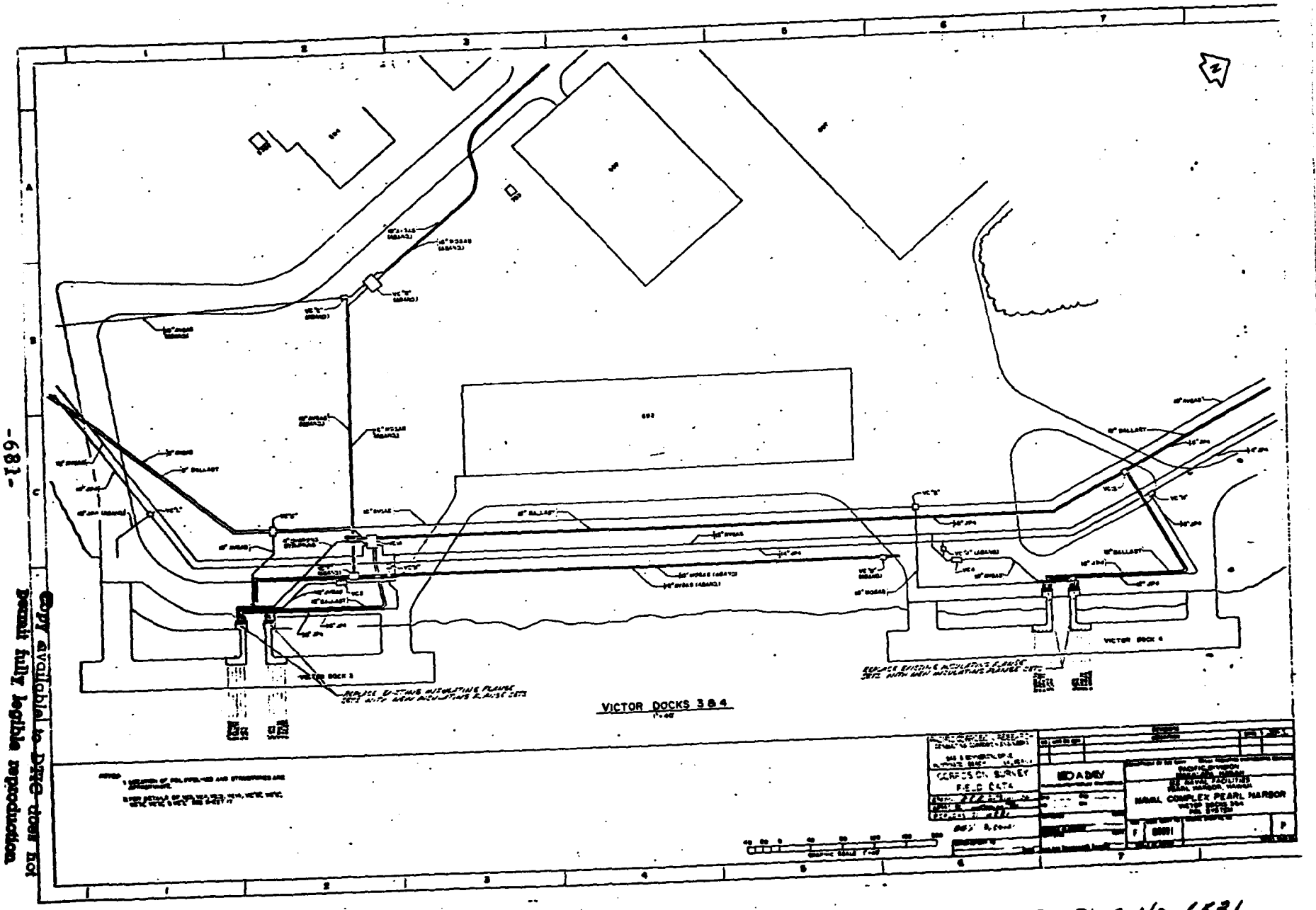

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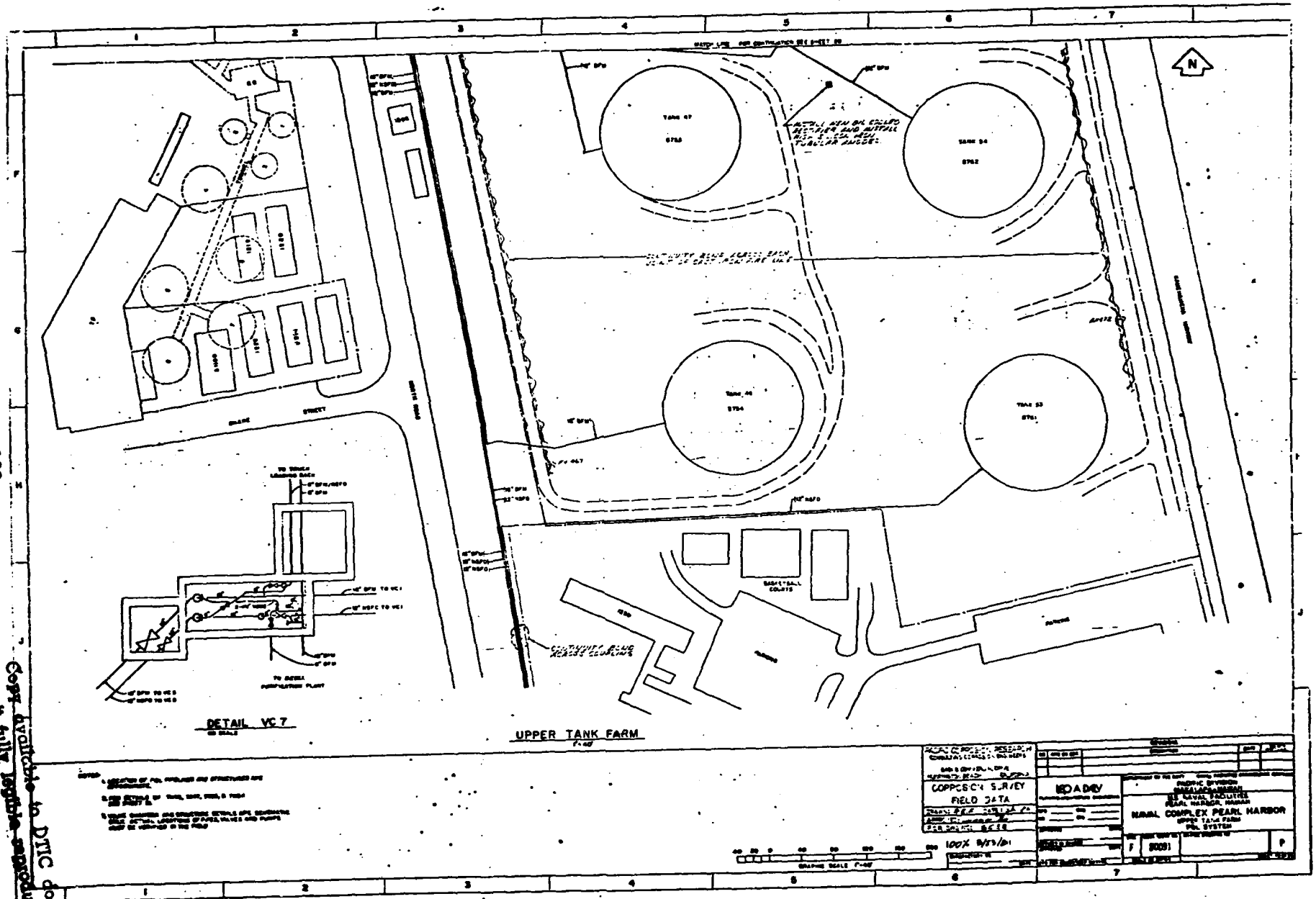

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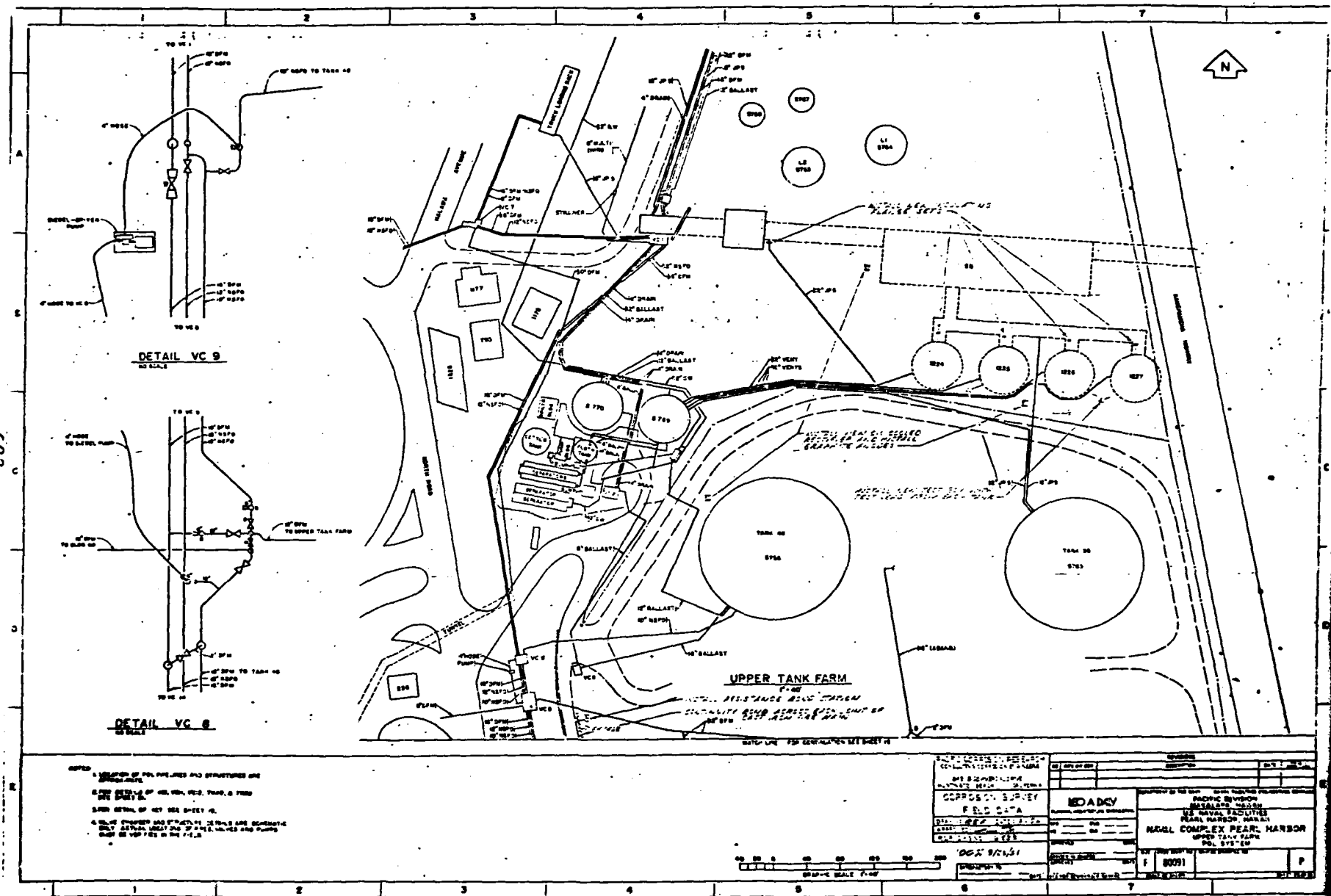

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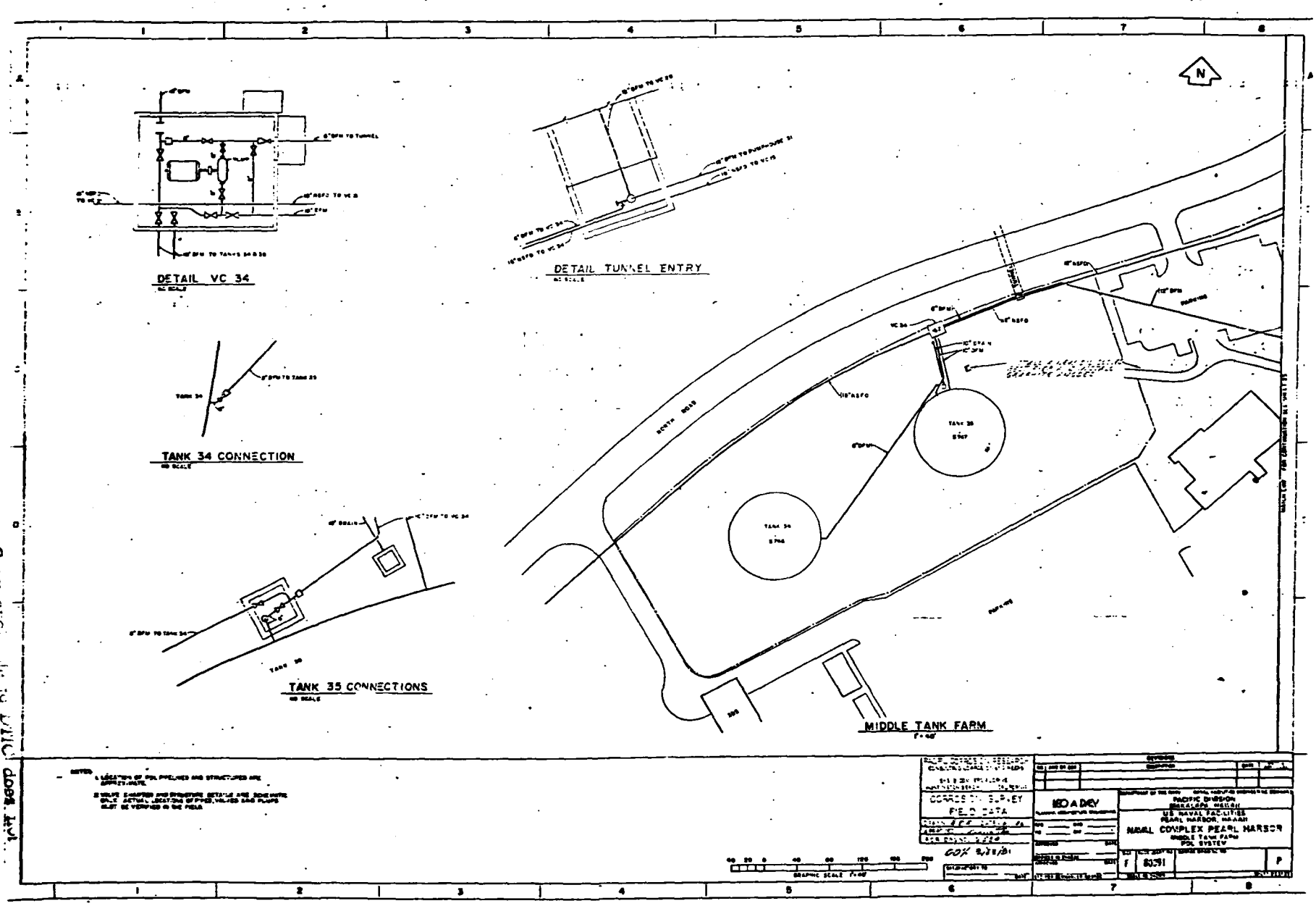

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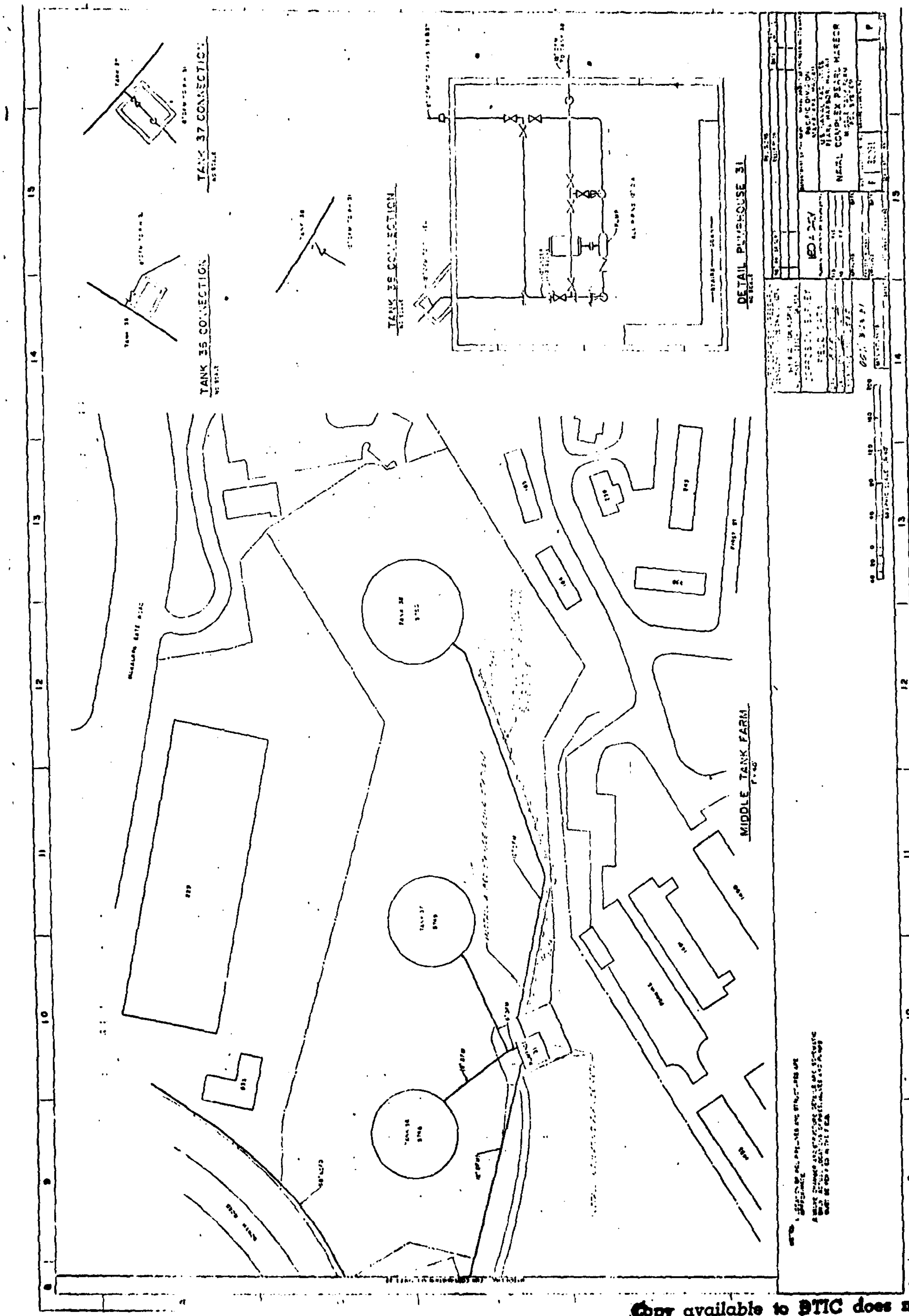

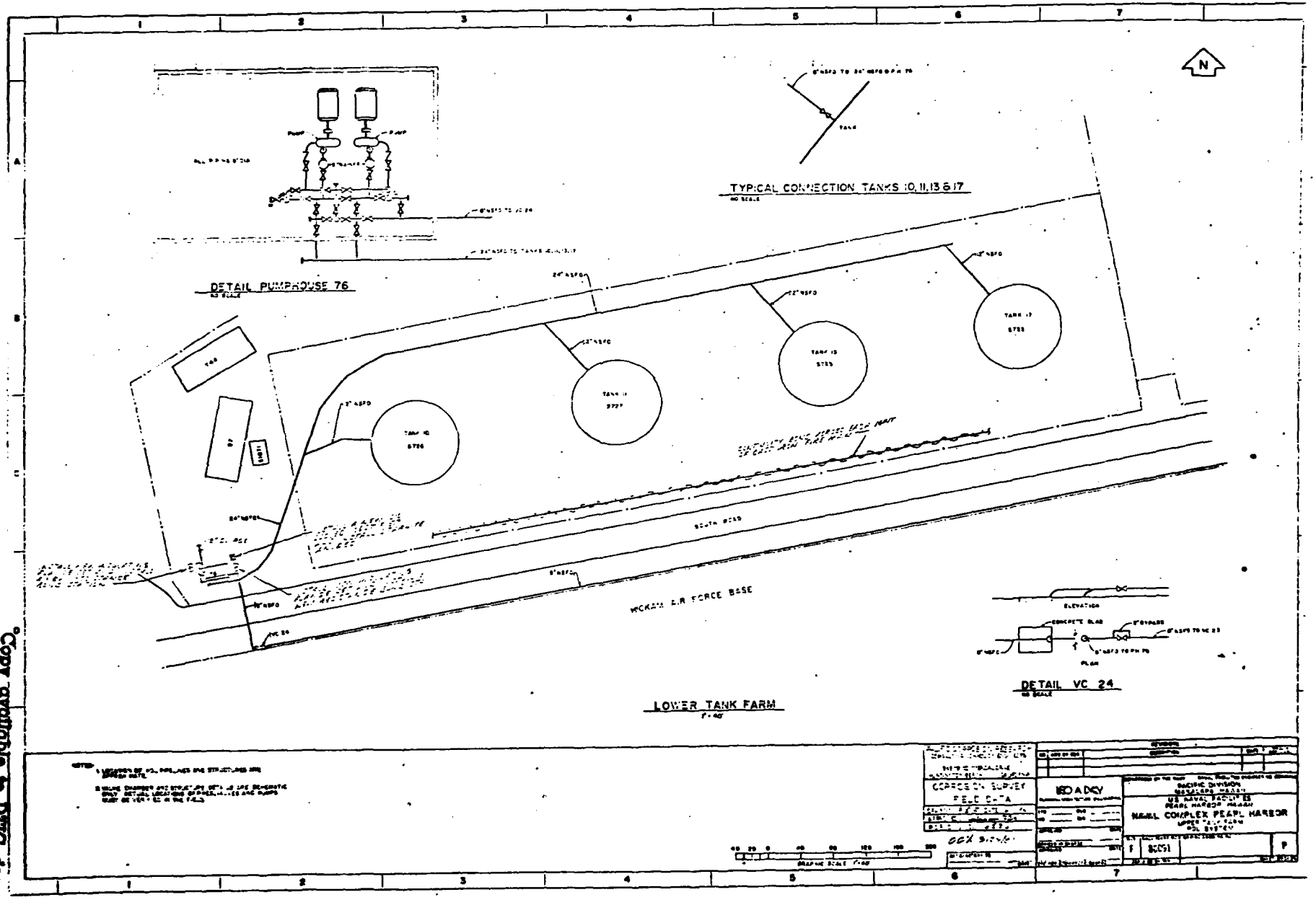

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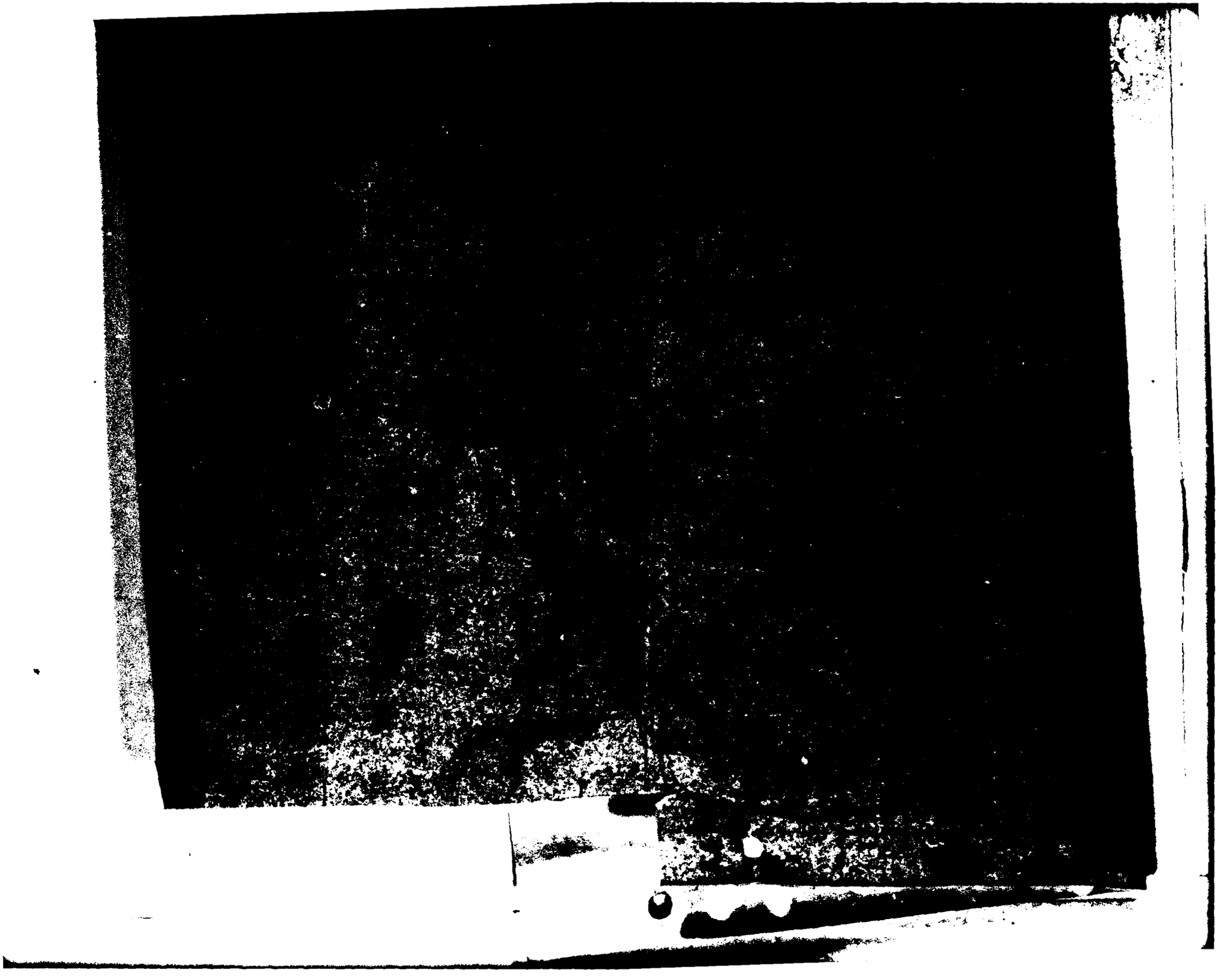

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